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Wednesday
November 28, 1979

Part II

Department of Energy

Office of Conservation and Solar Energy

Energy Performance Standards for New Buildings; Proposed Rule

DEPARTMENT OF ENERGY

Office of Conservation and Solar Energy

10 CFR Part 435

Energy Performance Standards for New Buildings; Proposed Rulemaking and Public Hearings

AGENCY: Department of Energy.

ACTION: Proposed rulemaking; notice of public hearings.

SUMMARY: The Department of Energy proposes to establish energy performance standards for new buildings to achieve the maximum practicable improvements in energy efficiency and increases in the use of renewable sources of energy. The standards will apply to the designs of new residential and commercial buildings.

The proposed standards consist of three fundamental elements:

- Energy Budget Levels for different classifications of buildings in different climates, expressed as an annual rate of energy consumption.
- A method for applying these Energy Budget Levels to a specified building design to obtain a specific annual rate of energy consumption, which is its Design Energy Budget.
- A method for calculating the estimated annual rate of energy consumption of a building design, which is referred to as its Design Energy Consumption.

The proposed rule requires that the Design Energy Consumption of a building design for a new building may not exceed its Design Energy Budget.

States and local governments will be encouraged to adopt, enforce, and implement the energy performance standards through their existing building codes, other construction control mechanisms, or an alternate approval process. Although such implementation is discussed in the preamble to this proposed rule, an implementation methodology is not formally proposed.

The Department anticipates that, after the final rule is promulgated, the standards will be revised periodically to reflect advances in energy conservation and renewable energy technologies, changes in energy prices and supplies, and knowledge gained from experience in administering the standards.

DATES: Written comments on this proposed rule and the Technical Support Documents, including the Draft Environmental Impact Statement, must be received by the Department on or before February 26, 1980. Five public hearings will be held, on the dates given in the table.

ADDRESSES: The hearings will begin at 9:30 a.m., local time. The hearings will be conducted as stated in Section 7.0 of the preamble to this proposed rule. The locations of the hearings are given in the table. Written comments and requests to speak at the hearings, as well as questions regarding the conduct of the hearings, should be directed to Joanne Bakos.

Interested persons are invited to participate in this rulemaking by submitting data, views, and comments to Joanne Bakos, Office of Conservation and Solar Energy, Department of Energy, Docket Number CAS–RM–79–112, Mail Station 2221C, 20 Massachusetts Avenue, NW., Washington, D.C. 20585.

City	Hearing date	Location	Requests to speak to be submitted by	Speakers selected notified by
Washington, D.C.	Jan. 28, 29, 30, 1980.	Bethesda Holiday Inn, 8120 Wisconsin Ave., Bethesda, Md.	Jan. 16, 1980	Jan. 23, 1980.
Atlanta, Ga	Feb. 4, 5, 6, 1980.	Atlanta Civic Center, 395 Piedmont Ave., N.E., Atlanta, Ga. 30308.	Jan. 16, 1980	Jan. 23, 1980.
Kansas City, Mo.	Feb. 4, 5, 6, 1980.	Holiday Inn, 1301 Wyandotte St., Kansas City, Mo. 64105.	Jan. 16, 1980	Jan. 23, 1980.
Los Angeles, Calif	Feb. 11, 12, 13, 1980.	Holiday Inn, Convention Center, 1020 South Figueroa St., Los Angeles, Calif. 90015.	Jan. 16, 1980	Jan. 23, 1980.
Boston, Mass	Feb. 11, 12, 13, 1980.	J. W. McCormack, Post Office and Courthouse Building, Post Office Square, Boston, Mass. 02102.	Jan. 16, 1980	Jan. 23, 1980.

FOR FURTHER INFORMATION CONTACT:

James L. Binkley, AIA (Buildings and Community Systems), U.S. Department of Energy, Office of Conservation and Solar Energy, Mail Station 2114C, 20 Massachusetts Avenue, NW., Washington, D.C. 20585, (800) 424–9040 (Continental U.S.), (800) 424–9081 (Alaska, Hawaii, territories and possessions), (202) 252–2855 (Washington, D.C.).

Joanne Bakos (Hearing Procedures), U.S. Department of Energy, Office of Conservation and Solar Energy, Mail Station 2221C, 20 Massachusetts Avenue, NW., Washington, D.C. 20585, (202) 376–1651.

Richard F. Kessler (Office of General Counsel), U.S. Department of Energy, Mail Station 3228, 20 Massachusetts Ave., NW., Washington, D.C. 20585, (202) 376–4543.

SUPPLEMENTARY INFORMATION: The following table of contents details the organization of this Notice of Proposed Rulemaking.

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7.0 Opportunities for Public Comments
8.0 A Guide to the Proposed Rule

The Proposed Rule

Technical Support Documents

In support of this proposed rule, the Department has developed ten Technical Support Documents. These documents provide detailed information on important aspects of the proposed rule and are referred to throughout the preamble. The Draft Environmental Impact Statement (Technical Support Document No. 7) will be available at the time of publication of this proposed rule in the **Federal Register**. The other documents will be available on or before December 19, 1979. All documents may be obtained at the addresses given below.

Number	Title	Administrative record number
1	The Standard Evaluation Technique.	9561.00
2	Statistical Analysis	9562.00
3	Energy Budget Levels Selection.	9563.00
4	Weighting Factors	9564.00
5	Standard Building Operating Conditions.	9565.00
6	Draft Regulatory Analysis.	9566.00
7	Draft Environmental Impact Statement.	9567.00
8	Economic Analysis	9568.00
9	Passive and Active Solar Heating Analysis.	9569.00
10	Climate Classification Analysis.	9670.00

Copies of the proposed rule and all of the Technical Support Documents, as well as other documents specifically identified in this proposed rule, may be obtained from and will be available for public review under Docket No. CAS–RM–79–112 in the following Offices, between the hours of 8:00 a.m. and 4:30

p.m., Monday through Friday, except Federal holidays:

- Department of Energy, Freedom of Information Officer, 150 Causeway Street, Boston, MA 02114, (617) 223–5207.
- Department of Energy 26 Federal Plaza, Room 3200, New York, NY 10007, (212) 264–4780.
- Department of Energy, 1421 Cherry Street, 10th Floor, Philadelphia, PA 19102, (215) 597–9067.
- Department of Energy, 1655 Peachtree Street, NE., Atlanta, GA 30309, (404) 881–2696.
- Department of Energy, 175 West Jackson Blvd., Room A333, Chicago, IL 60604, (312) 886–5170.
- Chicago Operations & Regional Office, 9800 South Cass Avenue, Argonne, IL 60439, (312) 972–2002.
- Department of Energy, P.O. Box 35228, Dallas, TX 75235, (214) 767–7701.
- Department of Energy, 324 East 11th Street, Kansas City, MO 64106, (816) 374–5182.
- Department of Energy, 1075 South Yukon Street, P.O. Box 26247, Belmar Branch, Lakewood, CO 80226, (303) 234–2420.
- Department of Energy, 111 Pine Street, 3rd Floor, San Francisco, CA 94111, (415) 556–7216.
- Department of Energy, 1992 Federal Building, 915 Second Avenue, Seattle, WA 98174, (206) 442–7303.
- Department of Energy, Freedom of Information Reading Room, Forrestal Building, 1000 Independence Ave., SW., Washington, D.C. 20585, (202) 252–5953.
- Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico, Attn: National Atomic Museum, Public Document Room, P.O. Box 5400, (505) 264–6938.
- Chicago Operations & Regional Office, 175 West Jackson Blvd., Chicago, IL 60604, Attn: Freedom of Information Office, Room A–136, (312) 353–5769.
- Department of Energy, Idaho Operations Office, 550 Second Street, Idaho Falls, ID 83401 Attn: R. L. Blackledge, Assistant to Mgr. for Public Affairs, (208) 526–1317.
- Morgantown Energy Tech. Center, P.O. Box 880, Morgantown, W.V. 26505, Attn: Dorthy Simon, Librarian, (304) 599–7184.

Single copies of the documents may also be obtained by contacting James L. Binkley at the address given previously.

The Draft Environmental Impact Statement only will also be available at the following offices, in addition to those previously listed:

- Department of Energy, Nevada Operations Office, Director, Office of Public Affairs, P.O. Box 14100, Las Vegas, NV 89114.
- Department of Energy, Oak Ridge Operations Office, P.O. Box E, Public Document Room, Oakridge, TN 37830.
- Department of Energy, Hanford Science Center, 825 Jaswin Avenue, Richland, WA 99352.

1.0 The Standards Program

1.1 Introduction

The Department of Energy (DOE) today proposes to amend Chapter II of Title 10, Code of Federal Regulations, to establish energy performance standards for new commercial and residential buildings. In August of 1976, in response to the need to encourage in new buildings greater conservation of depletable energy resources and the increased use of renewable energy resources, Congress passed the Energy Conservation Standards for New Buildings Act of 1976 (42 U.S.C. 6831–6840) (the Act). The Act mandated the development, promulgation, implementation and administration of energy performance standards for new buildings (the Standards). This proposed rule has been prepared by DOE in direct response to Section 304 of the Act, which calls for the development and promulgation of the Standards.

Responsibility for the development and promulgation of the energy performance standards was transferred from the Department of Housing and Urban Development (HUD) to DOE by Section 304(a), 42 U.S.C. 7154(a), of the Department of Energy Organization Act, Pub. L. 95–91, 42 U.S.C. 7101 *et seq.*

The proposed rule and this preamble are presented in a manner that DOE hopes will be easily understood by those who will be expected to comply with, or who may be affected by, the final rule, including: The general public; consumer, environmental, and public interest groups; the real estate community; State and local governments; public and private utilities; design professionals; builders; building product manufacturers; and others concerned with buildings.

This Notice of Proposed Rulemaking is presented in two parts: the preamble, and the proposed rule. The proposed rule, which includes four Appendices and three subparts, is presented at the end of this issuance, following the preamble.

The preamble, of which this section is a part, describes the Standards program and the contents of the proposed rule (Section 1.0); presents in summary form a description of the program conducted to develop the proposed rule (Sections 2.0 through 4.0); discusses issues surrounding implementation of the Standards (Section 5.0); summarizes the draft Regulatory Analysis proposed by DOE (Section 6.0); gives the procedures to be followed for public comment on the Standards and for the public hearings on the proposed rule (Section 7.0); and finally, gives an illustration of how the proposed rule could be applied to a building design process (Section 8.0).

1.1.1 Summary

Congress determined that significant amounts of energy were unnecessarily consumed for space conditioning and domestic hot water in newly constructed residential and commercial buildings, because such buildings lacked adequate energy conservation features. (Section 302(a) of the Act.)

To respond to this problem, Congress directed the development and promulgation of Standards for "new residential and commercial buildings which are designed to achieve the maximum practicable improvements in energy efficiency and increases in the use of nondepletable sources of energy." (Section 302(2)).

Such standards will reduce energy waste in new buildings, a major energy-using sector of the Nation's economy. Estimates show that buildings currently use about one-third of the total U.S. energy consumption. Research, outlined in Section 2.0 of this preamble, affirms the Congressional finding that major opportunities exist to reduce this energy consumption, while realizing significant savings in operating costs to building owners and users.

This reduction is expected to result from accelerated investments in energy conservation in buildings over and above what would result from market forces alone. For example, single-family residential buildings designed to comply with the proposed Standards might use between 22% and 51% less energy than current practice [1]; and commercial and multifamily residential buildings might use between 17% and 52% less energy, depending on the type of building and the climate.[2]

DOE's initial analyses also show that the proposed Standards will result in greater conservation than existing building standards, as well as recently revised standards such as a draft version (April 1978) of the Department of Housing and Urban Development (HUD) Minimum Property Standards [3] and the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) proposed Standard 90–75R (November 1977).[4]

[1] Technical Support Document No. 8, Economic Analysis.

[2] Average reductions for building types derived from Brown Associates, Inc., "Budget Percentiles for Baseline and Redesigned Commercial Type Buildings for Cities with TRY Weather Tapes" (Sept. 1979).

[3] Research on the HUD Minimum Property Standards is discussed in Technical Support Document No. 8, Economic Analysis.

[4] Research on ASHRAE 90–75R is discussed in a memorandum to DOE from AIA Research Corporation, "Preliminary Results of Potential Improvements to ASHRAE 90–75R to Determine Possible Equivalence to the Mean of the Phase-2 Redesign Buildings" (August 30, 1979).

As mentioned, significant savings are expected for building owners and users. Studies assessing the probable costs and benefits to individuals show that the total cost of owning and operating a building designed in compliance with the proposed Standards (i.e., the capital cost of the building and the energy costs for heating, cooling, ventilation, lights, vertical transportation, and domestic hot water will decrease compared to current practice (Technical Support Document No. 8, Economic Analysis)).

1.1.2 Summary Description of the Proposed Standards

The Act calls upon DOE to develop Standards for new buildings which are to be implemented at the State and local level through building codes. The Act defines Standards to mean:

"an energy consumption goal or goals to be met without specification of the methods, materials, and processes to be employed in achieving that goal or goals, but including statements of the requirements, criteria and evaluation methods to be used, and any necessary commentary." (Section 303(9) of the Act)

A building is defined in Section 303(2) of the Act as "* * * any structure to be constructed which includes provision for a heating or cooling system, or both, or for a hot water system."

The proposed Standards are applied during the design of a building and regulate its design energy conservation potential. They do not regulate the operation, maintenance or energy consumption of the building once built. The Standards thus take advantage of the great opportunity to save energy and to increase the use of renewable resources by requiring that buildings be designed to be energy efficient. The efficient operation and maintenance of the resulting energy-efficient buildings provides an opportunity to save even more energy.

The proposed Standards regulate the design of a whole building rather than prescribing requirements for its individual parts. This approach is markedly different from existing component performance standards, which specify the minimum energy-related performance of a building's parts, components or subsystems. Component-based standards do not consider that the same set of building components, assembled in different ways, can result in varying levels of design energy consumption for the whole building. Whole building performance standards take this into account by permitting a designer to meet an overall energy goal for a building by considering not only the efficiencies of parts of the building but also the tradeoffs among building components or among alternate overall design strategies.

The proposed Standards do not specify the methods, materials or processes used to meet the energy goals. As such, they can accommodate changes in design and technology over time.

The proposed Standards do not regulate only heat gain and heat loss through a building's skin. Instead, they set energy limits for the building as a whole. This includes projected combined energy use of specific energy using systems in a building such as the heating, cooling, lighting and domestic hot water systems.

The proposed Standards consist of three elements. First, Energy Budget Levels must be set for different classifications of buildings [5] in different climates.[6] The Energy Budget Levels are stated in terms of thousands of British thermal units per square foot of gross area of the building design per year (MBtu/sq. ft./yr).

Second, the proposed Standards provide the method for applying the Energy Budget Levels to a specific building design to obtain an annual rate of energy consumption, which is its Design Energy Budget. This method covers (1) buildings that have only one primary function, and (2) multifunctional buildings.

Third, the proposed Standards establish a method for calculating the estimated annual rate of energy consumption of a building design, which is referred to as its Design Energy Consumption. Accordingly, the Standards can be reduced to the simple design requirement that the Design Energy Consumption of a new building design may not exceed its Design Energy Budget.

Section 1.4 of this preamble describes in more detail the contents of each section of the proposed Standards, and Section 8.0 gives an example of how the proposed Standards might be used in a typical building design process.

[5] The classifications of building designs are given in the proposed rule. It should be noted that goals are not provided for three classifications, restaurants, industrial buildings, and mobile homes, at this time. These three classifications are all published "space reserved" for this proposed rule, pending the outcome of further research. Also, it should be noted that mobile homes are currently regulated under the provisions of the HUD Mobile Home Construction and Safety Standards and that, once the performance Standards are final, the HUD standards will be modified for compliance with the performance Standards.

[6] The climate conditions are included in the proposed Standards in response to the requirement that they "* * * take account of * * * climate variations among the different regions of the country." (Section 304(b) of the Act).

1.1.3 Summary Description of the Standards Program

The Standards program is comprised of both the development of the Standards and their implementation. The development of the Standards is dealt with in this proposed rule.

The implementation of the Standards, which is the second part of the program, is not formally proposed in this NOPR. However, issues surrounding implementation are discussed in Section 5.0. Implementation will center on the concept that States and local governments will be encouraged "to adopt and enforce such standards through their existing building codes and other construction control mechanisms, or to apply them through a special approval process." (Section 302(b)(3) of the Act)

1.2 Advance Notice of Proposed Rulemaking

The effort to develop the proposed Standards has included an Advance Notice of Proposed Rulemaking (ANOPR), published in the **Federal Register** on November 21, 1978, and three public meetings, held in December 1978 in Washington, D.C., Chicago, IL and San Francisco, CA. Thirty-four individuals testified at the public meetings and 186 written comments were submited. The purpose of the ANOPR and the public meetings was to solicit public comment on the status of the development program and a number of issues unresolved at that time. The comments received were central in shaping the additional research that followed the ANOPR, as well as the form and presentation of this Notice of Proposed Rulemaking (NOPR). Public comment is also requested on this proposed rule, and the comments received within the specified comment period will be considered in the formulation of the final rule.

1.3 Elements of the Proposed Rule

The proposed rule has three major subparts. Subpart A, "The Performance Standards," is presented in detail. Subpart B, "Implementation," and Subpart C, "Administrative Review," are to be published in the future. This means that these subparts are still being developed, but are expected to become part of the final rule.

The proposed rule also has four Appendices. Appendix I, "Energy Budget Level Tables," contains the proposed Energy Budget Levels for single-family residential, commercial and multifamily residential buildings for identified building classifications and for various geographic locations.

Appendix II, "Climate Tables," sets forth the procedures for selecting the climate conditions applicable for locations not included in the tables in Appendix I.

Appendix III, "Approved Alternate Evaluation Techniques," and Appendix IV, "Model Codes and Standards," are expected to be published in the final rule.

The following discussion is intended to serve as a guide to understanding these elements of the proposed rule and is organized in the same manner as the proposed rule.

1.4 Content of the Proposed Rule

Subpart A, "The Performance Standards," has six sections, as described below.

1.4.1 Purpose and Scope (§ 435.01)

This section of the proposed rule describes why the Standards are being proposed, gives a brief explanation of their nature and indicates what the Standards are generally expected to accomplish. For the most part, this is a direct response to language contained in the Act.

1.4.2 Definitions (§ 435.02)

This section of the proposed rule defines terminology used throughout the proposed rule and is crucial to its proper interpretation. Some of the terms used are widely recognized by the building industry, but are given precise meaning for their use in the proposed rule.

1.4.3 Requirements for the Performance Standards (§ 435.03)

This section of the proposed rule sets forth the design requirements of the Standards and the method for determining whether a building design complies with the Standards. Simply stated, the Design Energy Consumption of a new building must not exceed the Design Energy Budget for that building type in its applicable climate area. This requirement is the essence of the proposed rule.

The proposed Energy Budget Levels are displayed in Appendix I. The research program that was used as the basis for selecting the proposed Energy Budget Levels is described in Section 2.0 of the preamble. The reasons for this are described in Section 3.0.

1.4.4 Building Design and Building Function Classifications (§ 435.04)

This section of the proposed rule provides detailed definitions of the building design and building function classifications covered by the proposed Standards. As such, the section provides guidance in determining the applicable Design Energy Budget for a given building design and is the first major element used in that determination. The procedure used to develop the building classifications is described in Section 2.4.3 of the preamble.

1.4.5 Selection of Applicable Climate Conditions (§ 435.05)

This section of the proposed rule outlines a procedure whereby a proposed building design may be related to any location in the United States, either by proximity or by similarity in weather characteristics, to one or more of the 78 Standard Metropolitan Statistical Areas (SMSA's) and cities. It refers to Appendix II, which provides climate data for the 78 SMSA's and cities. It also sets forth procedures for selecting applicable climate conditions in localities outside those listed. This section is the second major element used to determine the applicable Design Energy Budget for a given building design and is discussed at greater length in Section 2.4.5 of the preamble. An extensive review of DOE's research concerning the relationship between Climate and Design Energy Consumption is presented in Technical Support Document No. 10, Climate Classification Analysis.

1.4.6 Procedure for Establishing Alternate Evaluation Techniques (§ 435.06)

This section of the proposed rule establishes a procedure whereby a calculation method other than the Standard Evaluation Technique can be submitted for consideration as an approved alternate. The procedure requires the submission of data and information for review and evaluation.

A discussion of evaluation techniques is provided in Section 4.0 of the preamble. A comprehensive overview of energy calculation methods in general, and the Standard Evaluation Technique in particular, is provided in Technical Support Document No. 1, The Standard Evaluation Technique.

1.4.7 Subpart C, Administrative Review

Subpart C, "Administrative Review," is expected to provide a procedure for administrative interpretations of and exceptions to the Standards. It is expected to include exceptions procedures for designs involving:

- Special health and safety requirements or considerations.
- Unique climate conditions.
- Difficult problems in calculating Design Energy Consumption.
- Unique building classifications.
- Other matters or concerns, as determined by DOE.

1.5 Updating the Standards

As required by Section 304(c) of the Act, "The Secretary * * * shall periodically review and provide for the updating of [the] Standards."

DOE has considered two approaches for updating the Standards. The first is to provide for a review of the Standards for possible updating at periodic intervals (perhaps every three to five years). The other alternative is to propose a long-term plan with Energy Budget Levels defined for a period of 10 years or more. Such a long-term schedule could provide a degree of certainty, as well as more lead time for the building industry. If technical or economic circumstances dictate, such a long-term schedule could be revised.

DOE would like to receive comments on whether periodic updating or predetermined Energy Budget Levels is preferable.

1.6 Monitoring the Standards

Sections 311 (1), (2) and (3) of the Act require the Secretary to "* * * monitor the progress made by the States * * *," to "* * * identify any procedural obstacles or technical constraints inhibiting implementation * * *," and to "* * * evaluate the effectiveness * * *" of the Standards. In addition to answering these requirements, a monitoring plan may respond to such questions as:

- How can the accomplishments and costs of the regulation or program be measured?
- What kinds of information are required to measure program costs and benefits and how can this information be collected?

The following measures may be used to evaluate the accomplishments and costs of the Standards:

- The extent of compliance as measured by the percentage of newly constructed buildings complying with the Standards.
- The amount of energy saved, expressed by fuel type, in Btu's and in dollars, due to the Standards. This will be accomplished by the use of national surveys of the design and actual energy consumption of a stratified sample of pre-Standards construction and a similar sample of post-Standards construction. Comparisons of the difference in energy consumption by building type will indicate the difference the Standards have had, and the results will be aggregated to allow for the calculation of the national energy savings.

• The extent of additional cost due to compliance with the Standards, including user costs, design costs, building construction costs, State and local certification costs, and costs incurred to satisfy any alternate approval process.

• The cost per unit of energy saved, using the data referred to above.

DOE will coordinate data collection with the Energy Information Agency (EIA) and obtain energy consumption information from EIA's national residential and nonresidential building surveys by building type. The latest pre-Standards survey information will be compared to the initial post-Standards survey.

DOE would like to receive comments on its proposed monitoring plan.

1.7 Summary

The above section provides an overview of the Standards program and the elements of the proposed rule. Section 2.0, which follows, details the research activities conducted in support of the program, in order to develop an information base from which DOE could determine not only the proposed Energy Budget Levels, but also the most appropriate structure and unit of measure for presenting the Standards.

2.0 The Research Effort

In developing the proposed rule, DOE conducted analyses of building designs relative to energy efficiency, stimulation of the use or renewable resources, building functions and operating conditions, environmental impacts, institutional resources, habitability, economic cost and benefit, and impacts on affected groups.

When the Act was passed, there was little information available on the Design Energy Consumption of buildings and thus limited technical information on which to establish Energy Budget Levels. Furthermore, there was little information on the economic, environmental, or regulatory impacts of requiring that new buildings be designed to use less energy than current practice. In order to establish reasonable Energy Budget Levels, this information had to be developed. The research program addressed these issues.

The research effort was both extensive and complex. It consisted of concurrent research activities in a number of areas, over more than a two-year period, with many of the research activities exploring new issues.

The following is a guide to the contents of this section:

2.1 Introduction
2.1.1 Organization of the Research
2.1.2 Research Chronology
2.2 Research to Develop Energy Budget Levels
2.2.1 Commercial and Multifamily Residential Buildings
2.2.2 Single-Family Residences
2.2.3 Mobile Homes
2.3 Additional Research Affecting Energy Budget Levels
2.3.1 Environmental Issues
2.3.2 Commercial and Multifamily Residential Buildings
2.3.3 Single-Family Residences
2.4 Research Affecting the Format of the Energy Budget Levels
2.4.1 Weighting Factors
2.4.2 Renewable Sources of Energy
2.4.3 Building Design Classifications
2.4.4 Standard Building Operating Conditions
2.4.5 Climate
2.4.6 Unit of Measure

2.1 Introduction

This section provides a general description of the information upon which DOE based this proposed rule. The introduction describes the research program and its chronology.

The research program pursued two general directons: (1) It provides an information base for determining appropriate Energy Budget Levels; and (2) it develops a structure and unit of measure for the proposed Standards, to reflect the fuels used, expected types of building uses, building operating conditions, and climate variations.

2.1.1 Organization of the Research

During the development of the information base, the organizational structure of the program shifted considerably, because of the changes in DOE and HUD responsibilities over time, and because of the shift in emphasis of the research program from strictly an energy analysis to an energy, economic, environmental and regulatory analysis.

The structure of the initial research effort is shown in Figure 2.1. The initial research program was directed by HUD (Box 1). The HUD effort was coordinated with the U.S. Energy Research and Development Administration, a predecessor of DOE (Box 2). Under HUD's direction, The American Institute of Architects, AIA Research Corporation (AIA/RC) (Box 4) managed the research program. A technical Advisory Group (TAG) (Box 3) to AIA/RC provided general technical advice in key areas. An Educational Advisory Group provided advice on the structuring of certain elements of the buildings design experiments (Box 5).[7]

The current organization and management of the research program is shown in Figure 2–2. The program is managed by DOE (Box 1) in coordination with other Federal agencies (Box 2).

The initial research program is continuing, with a focus on life-cycle cost studies on commercial buildings and mobile homes, an analysis of competent performance standards, climate analysis, building function analysis, statistical analysis and data analysis (Box 3). DOE is also undertaking new research which includes economic analysis, environmental analysis, life-cycle cost studies for single-family residences, building classification analysis, weighting factor analysis, development of an evaluation technique and preparation of a regulatory analysis (Boxes 4 and 5).[8]

2.1.2 Research Chronology

The research program to date has been conducted in three phases (see Figure 2–3). Phases 1 and 2, conducted in 1977 through mid-1978, focused on the development of an energy information base for current building design. Research in the third phase includes energy, economic and environmental studies.

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[7] The major research activities included building surveys, statistical studies, building design experiments, data collection, data processing, building classification studies, design contract administration and climate classification studies (Box 6). Major subcontractors to AIA/RC included: Syska & Hennessey, Inc., and S&H Information Systems, Inc., for data collection, analysis and processing for commercial and multifamily residential buildings; The Ehrenkrantz Group, Inc., for building classification and code studies; Brown Associates, Inc., for sample design and statistical analysis; the National Association of Home Builders Research Foundation (NAHB/RF), for residential data collection, analysis and processing; T. R. Arnold & Associates, for mobile home data analysis and processing; Stephen Winters Associates, for mobile home cost analysis; DTM, Inc., for statistical analysis; Heery & Heery, Inc., for design contract administration; Bickle-CM, Inc., for comparative analysis of computer program results; Ayres Associates, for comparative analysis of computer program results; Duke University Center for the Study of Energy Conservation, for comparative analysis of results of computer and manual calculation results; and R&D Associates, Inc., for climate analysis.

[8] The major contracts have been further architectural and engineering research activities, supported by most of the same general subcontractors as in the initial period, plus: Hanscomb Associates, Inc., for commercial life-cycle cost studies; Reynolds, Smith and Hills, for mobile home life-cycle cost studies; IDC, Inc., for building function analysis; and with continuing advice from the TAG. Battelle Pacific Northwest Laboratory and Brookhaven National Laboratory are managing and conducting major economic, environmental, life-cycle cost and related analyses, with assistance from Lawrence Berkeley Laboratory, Los Alamos Scientific Laboratory, and Oak Ridge National Laboratory. OAO Corporation is providing program support and conducting a Regulatory Analysis, with assistance from Thomas Vonier Associates, Inc.

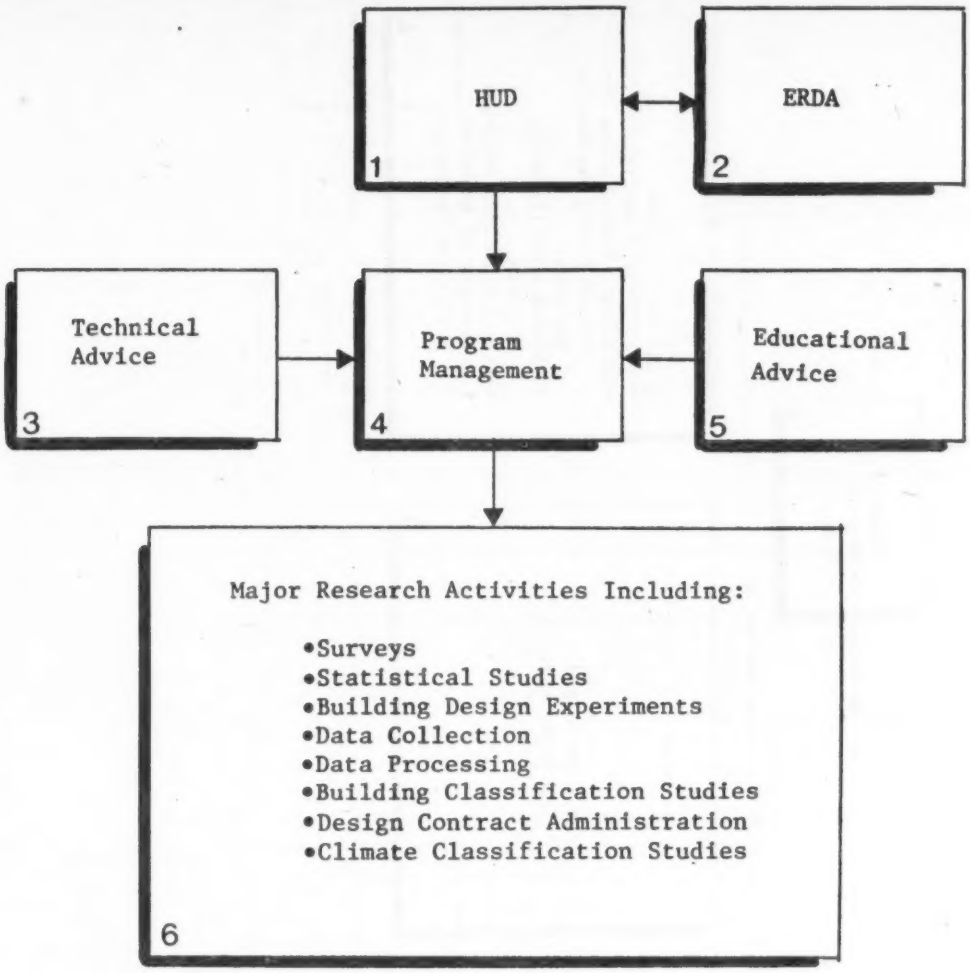
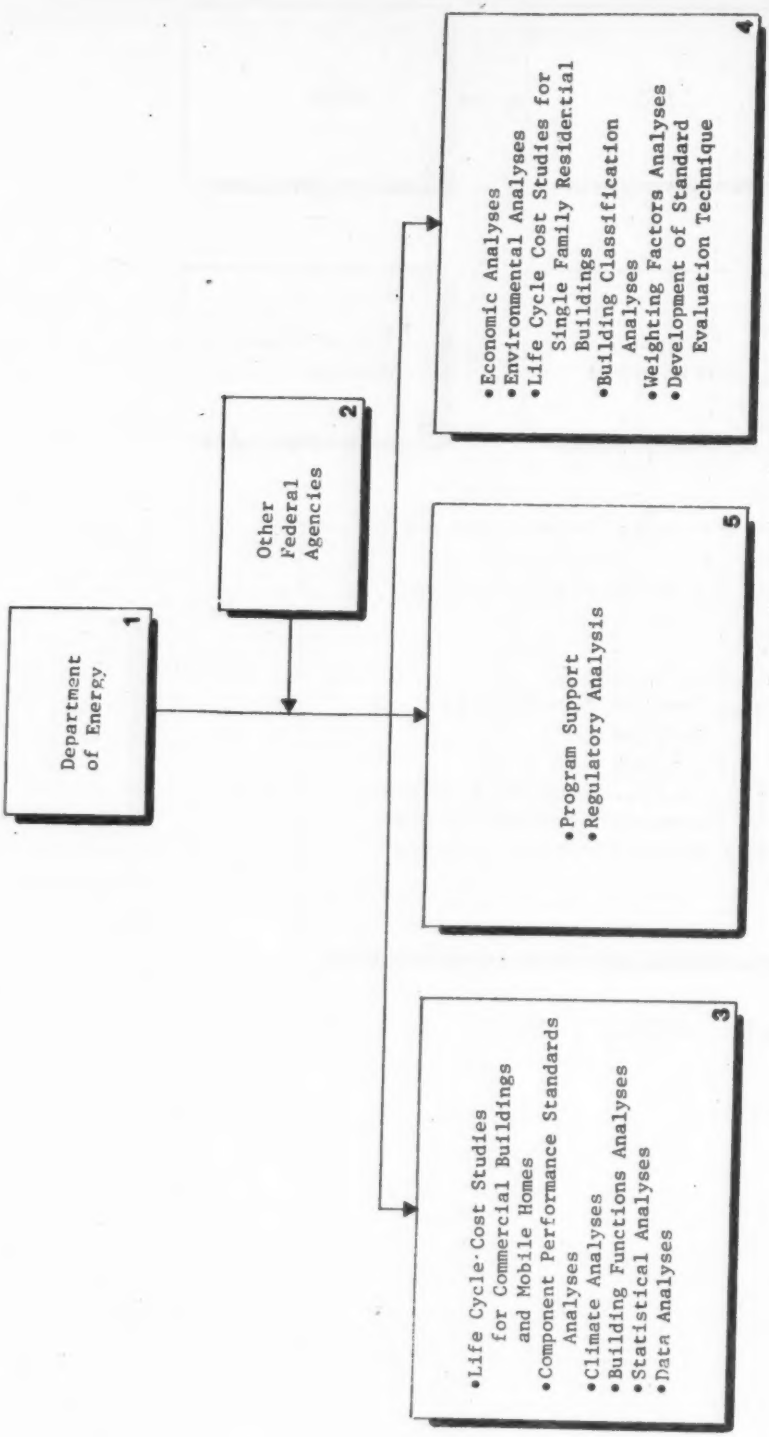


FIGURE 2-1: ORGANIZATION - PHASES 1 AND 2

FIGURE 2-2: CURRENT ORGANIZATION



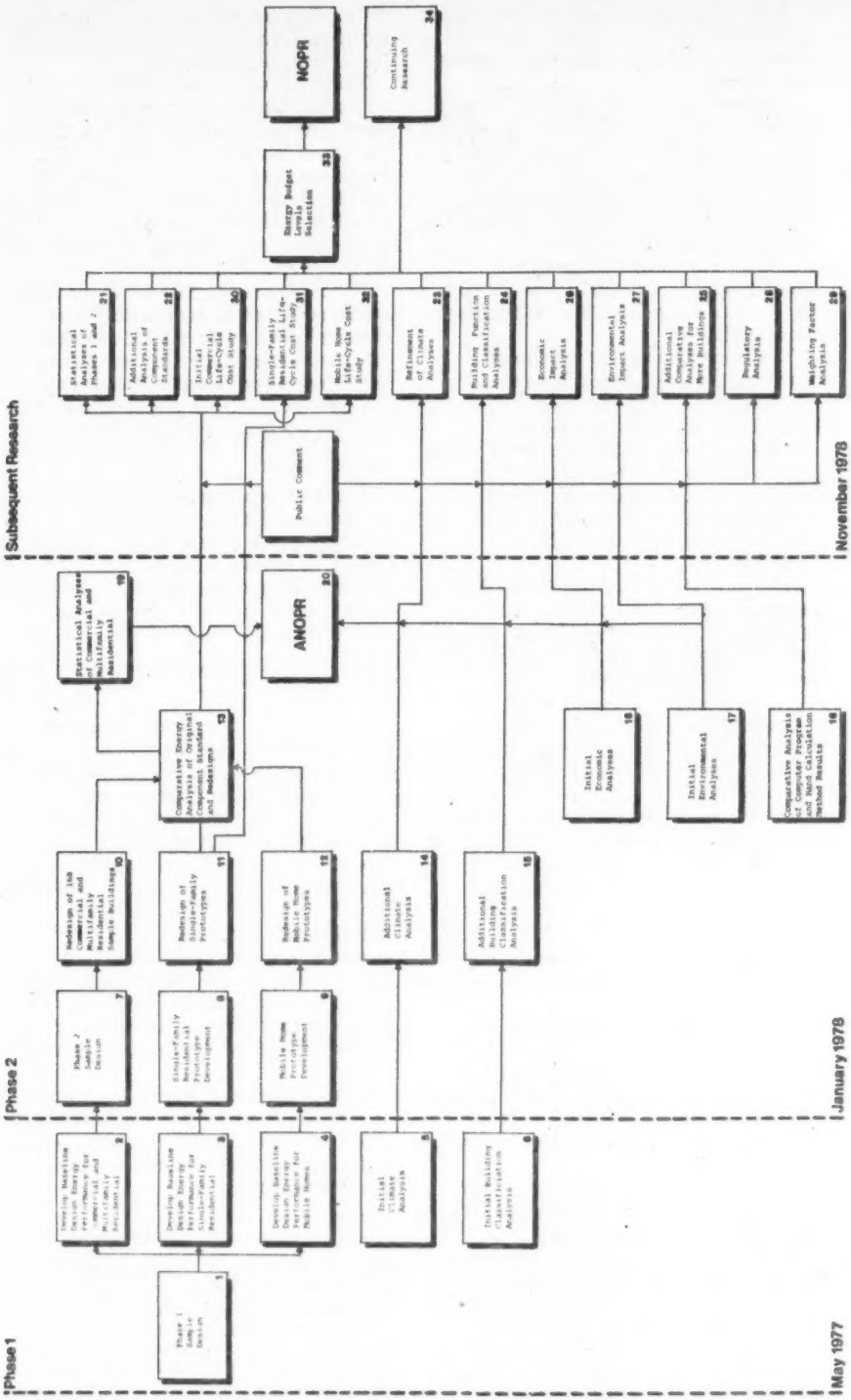


FIGURE 2-3: THE RESEARCH PROGRAM

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To provide a baseline of current building design practice, Phase 1 consisted of surveying and analyzing samples of commercial (Box 1), multifamily residential (Box 2), and single-family residential buildings (Box 3), and mobile homes (Box 4) for which construction began before the end of 1976. Such buildings represented the first generation of buildings designed after the 1973 oil embargo. Therefore, DOE concluded that their designs reflected greater concern for energy conservation in comparison with buildings designed prior to 1973. Phase 1 also included the first climate analysis (Box 5) and building classification analysis (Box 6) of the research program.

Phase 2 consisted of more detailed energy analyses of a sub-sample of the Phase 1 buildings (Box 7), or of prototype buildings (Boxes 8 and 9) derived from the Phase 1 sample. Redesign efforts were conducted for each major building category (commercial and multifamily residential, single-family residential and mobile home), and estimates of design energy requirements [9] were developed by building type (Box 13):

1. As originally designed for construction in 1975–1976.

2. As modified to conform to the minimum component performance requirements of existing energy standards and guidelines.

3. As redesigned to achieve maximum practicable levels of energy conservation in 1978 (referred to as the redesigns).

The analysis of climate (Box 14) and building classifications (Box 15), and the statistical analysis of the commercial and multifamily residential building samples (Box 19) were continued in more detail, a comparative analysis of computer program and manual calculation method results was conducted (Box 18), and economic (Box 16) and environmental (Box 17) analyses were initiated.

The research effort at this point provided the information base to support the ANOPR (Box 20).

In the third phase, subsequent analyses were conducted on three broad fronts. First, additional research was required to address energy related issues that surfaced during the research in Phases 1 and 2. These efforts included:

- Further statistical work to derive estimates of the total population of commercial and multifamily residential buildings from the results of the Phases 1 and 2 samples (Box 21).
- Continued examination of the design energy requirements resulting from the application of component performance standards and guidelines (Box 22).
- Refined climate analysis (Box 23).
- Analysis of the energy requirements of various building functions (Box 24).
- Comparison of energy analysis calculation results for more buildings (Box 25).

Second, DOE studied major economic, environmental and regulatory impacts. These included:

- Analyzing the potential national economic impact of the proposed Standards under a number of possible alternative future conditions and writing the Draft Economic Analysis (Box 26). (See Technical Support Document No. 8, Economic Analysis.)
- Conducting an assessment of the potential environmental impacts of the proposed Standards and writing the Draft Environmental Impact Statement (Box 27). (See Technical Support Document No. 7, Draft Environmental Impact Statement.)
- Conducting the initial regulatory analysis which examined alternative forms of and alternatives to the proposed rule, and writing the Draft Regulatory Analysis (Box 28). (See Technial Support Document No. 6, Draft Regulatory Analysis.)
- Developing and applying weighting factors to derive proposed Energy Budget Levels that take into account the value to the Nation of providing different types of fuel to a building (Box 29). (See Technical Support Document No. 4, Weighting Factors.)

Third, life-cycle cost studies for each of the three major building categories were initiated (Boxes 30, 31, 32). (See Technical Support Document No. 8, Economic Analysis.) The objective of the life-cycle cost studies was to provide an additional information base to assist in the selection of Energy Budget Levels for the proposed Standards (Box 33).

The research program provided DOE with a substantial information base obtained through an extensive research program. To further refine and verify this information base, DOE plans to undertake additional research (Box 34).

2.2 Research To Develop Energy Budget Levels

This section describes the research program conducted to provide information for determining proposed Energy Budget Levels for: (1) Commercial and multifamily residential buildings, (2) single-family residences, and (3) mobile homes.

2.2.1 Commercial and Multifamily Residential Buildings

During Phase 1, a survey was made of some 3,200 buildings for which construction began in 1975–1976. This provided a baseline representing "current" design practices. The sample represented 12 different building classifications, based on the F. W. Dodge structural classification system.[10] From this sample, responses were collected and analyzed for 1,661 buildings. To permit regional climate variation to be surveyed and analyzed, an initial climatic classification of seven heating/cooling degree-day regions was used for analysis purposes (See Section 2.4.5).[11]

An abbreviated form of a proprietary energy analysis computer program called AXCESS was used to calculate design energy requirements for the building designs.[12]

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[9] The design energy analyses in Phases 1 and 2 weighted each fuel used in terms of building site values. Design energy estimates at the site boundary are referred to throughout as design energy requirements, to distinguish them from Design Energy Budget and Design Energy Consumption estimates, which include weighting factors that reflect the value to the Nation of providing different kinds of fuel to a building site. This is discussed in Section 2.4.1 of this preamble.

The design energy requirements for commercial and multifamily residential buildings include energy for heating, cooling, ventilation, exhaust fans, artificial lighting, domestic hot water, and elevators and escalators. For single-family buildings, the design energy requirements include energy for heating, cooling and domestic hot water.

Other potential energy consuming systems or devices associated with the activities within a building are not necessary for maintaining comfort conditions for human occupancy, nor for maintaining conditions for the nonrefrigerated storage of products (in the case of warehouses). This type of energy use is referred to as "process" use and is not included in the design energy requirements of a building design. Examples of process energy requirements would be those for computer operations, commercial kitchen equipment, or laundries. DOE is considering research to develop a better understanding of the relationship between process energy use and the components of the design energy requirements. For single-family residences, contributions from major appliances were estimated as internal loads in the life-cycle cost analysis. However, the average requirement to operate such appliances was not included in the analysis.

[10] U.S. Department of Housing and Urban Development and U.S. Department of Energy. "Phase One/Base Data for the Development of Energy Performance Standards for New Buildings, Task Report: Sample Design" (Jan. 1978).

[11] U.S. Department of Housing and Urban Development and U.S. Department of Energy. "Phase One/Base Data for the Development of Energy Performance Standards for New Buildings, Task Report: Climate classification" (Jan. 1978).

[12] U.S.D. Department of Housing and Urban Development and U.S. Department of Energy, "Phase One/Base Data for the Development of Energy Performance Standards for New Buildings, Task Report: Data Analysis" (Jan. 1978); also, "AXCESS," (Alternate Choice Comparison for Energy System Selection) a proprietary computer program owned by the Edison Electric Institute (EEI). S&H Information Systems, Inc., has developed

Footnotes continued on next page

In Phase 2, a subsample of 168 buildings from the 1,661 in the Phase 1 survey was selected, using random techniques to assure a respresentative sample.[13] The building classification system was refined to include 16 categories.[14]

HUD contracted with architects and engineers responsible for the designs of the original buildings to redesign their buildings to use less energy. HUD developed guidelines for the redesign effort, and provided assistance to the redesign teams from knowledgeable consultants and through written technical materials.[14] The design teams were instructed to keep construction costs in the same general range as the original buildings.

In a separate effort, the original designs of the Phase 2 buildings were modified to meet two building energy standards (the November 1977 draft proposed ASHRAE 90–75R and the April 1978 draft version of the HUD Minimum Property Standards).[14] This was done to estimate the effect these standards would have on the design energy requirements of the building sample and to compare these standards with the design energy requirements of the redesigns. The HUD standard, a component performance standard, was applied to multifamily residential buildings; the component performance sections of ASHRAE 90–75R were applied to all other commercial buildings in the Phase 2 sample.[14]

Once all the redesign data had been collected, a more detailed version of AXCESS was used to estimate the design energy requirements of the original, redesigned, and modified buildings.[14] The major results of Phase 2 were:

- The calculation of design energy requirements for a sample of 168 buildings for which construction began in 1975–1976.
- The calculation of design energy requirements that could be achieved by using more energy conserving design techniques.
- The calculation of design energy requirements that could be achieved by using the minimum component performance requirements of the two standards, ASHRAE 90–75R and the HUD Minimum Property Standards.

Statistical Analysis

Using the Phases 1 and 2 sample building results, a statistical analysis was conducted which related the smaller Phase 2 sample to the larger Phase 1 sample. Design energy requirement calculations for each building classification were then developed for the entire population of buildings represented by the Phases 1 and 2 samples (see Technical Support Document No. 2, Statistical Analysis). Estimated energy requirements were derived for both the original and redesigned buildings. These estimates were adjusted using a procedure based on the results of the climate analysis described in Section 2.4.5. DOE used the estimates for each building classification in 78 SMSA's and cities in selecting the proposed Energy Budget Levels for each commercial and multifamily residential building classification presented in the proposed standards. (See Section 3.2 of this preamble and Technical Support Document No. 3, Energy Budget Levels Selection.)

Economic Analysis

The Economic Analysis examined the economic consequences of different levels of Design Energy Consumption achievable by the Phase 2 redesigns to determine whether the strategies contained in those redesigns were economically desirable and achievable (see Technical Support Document No. 8, Economic Analysis). "Net present values" [15] were calculated for each building classification and were analyzed to determine whether, on a discounted basis, future energy savings due to the redesigns would exceed increased capital and operating costs. DOE has estimated that the Phase 2 redesigned buildings had an average construction cost increase in the range of 3–5% from the original buildings.

Net present values were calculated from the perspective of the building owner, the occupant, and the Nation as a whole. Because the average net present value for each redesign building classification was positive, the redesigns were determined to be cost effective and economically achievable.

Analysis of Component Performance Standards

A study was conducted to measure the potential improvements in design energy requirements which the original buildings in the Phase 2 sample might have achieved had they been designed to meet exactly the minimum component performance requirements of ASHRAE 90–75R. During the Phase 2 analysis, the inability of the computer program used to model some important requirements, such as "deadband" thermostat control,[16] plus limitations in the manner in which the analysis was to be made, as well as difficulties encountered in interpreting ASHRAE 90–75R, resulted in an inconclusive analysis by the end of Phase 2.[17]

Therefore, in the subsequent research, refinements were made to the methodology, and the computer program was enhanced to include modeling capabilities required for a more complete analysis of ASHRAE 90–75R. In addition, a thorough review has been conducted of the interpretations made of key sections of that standard.

DOE also intends to continue its analysis of issues associated with implementing the Standards for commercial and multifamily residential buildings. One important area of this work concerns the manner in which the existing HUD Minimum Property Standards for multifamily residential buildings, and standards based on ASHRAE 90–75, can be made equivalent to DOE's proposed Standards.[18]

Preliminary results of this analysis are discussed in Section 3.2.9 of this preamble.

2.2.2. Single-Family Residential Buildings

The sequence of research tasks performed to support DOE's determination of the proposed Energy Budget Levels for single-family residential buildings is illustrated in

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two versions of this program, which were used in the research. One version uses a small number of data points and uses one day per month as its basis for calculation. The second version contains additional facilities over the EEI version. These two versions are referred to in the balance of this document as AXCESS.

DOE has inspected the available documentation for the program. The documentation examined includes the AXCESS Energy Analysis Reference Manual and AIA Research Corporation, "Basis of Engineering Logic in the S&H Information Systems AXCESS Program" (May 1979). Also see footnote 14.

[13] Brown Associates, Inc., "The Sample Design for Phase Two of the Development of Energy Performance Standards for New Buildings" (March 1978).

[14] U.S. Department of Housing and Urban Development and U.S. Department of Energy "Phase Two Report for the Development of Energy Performance Standards for New Buildings, Task Report: Commercial and Multi-Family Residential Buildings" (Jan. 1979).

[15] "Net present value" as used herein refers to the discounted value of the projected energy savings in new buildings less the investment and operating costs necessary to achieve those reductions in energy use.

[16] "Deadband" thermostat control means a control system for heating and cooling which allows minimum heating and cooling within a specified indoor temperature range (e.g., 68°F to 78°F). The controls attempt to maintain conditions by providing heating or cooling only when the indoor temperature is outside of the specified range.

[17] See footnote 14.

[18] AIA Research Corporation Memorandum, "Preliminary Results of Potential Improvements to ASHRAE 90–75R to Determine Possible Equivalence to the Mean of the Phase 2 Redesign Buildings" (Aug. 1979).

Figure 2–4. Phase 1 started with an analysis of an existing National Association of Home Builders Research Foundation (NAHB/RF) survey of over 120,000 houses constructed in 1975 and 1976 (Box 1).[19] This large sample encompassed all major varieties of single-family and multifamily low-rise residential construction throughout the country.

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[19] U.S. Department of Housing and Urban Development and U.S. Department of Energy. "Phase One/Base Data for the Development of Energy Performance Standards for New Buildings. Task Report: Residential Data Collection and Analysis" (Jan. 1978).

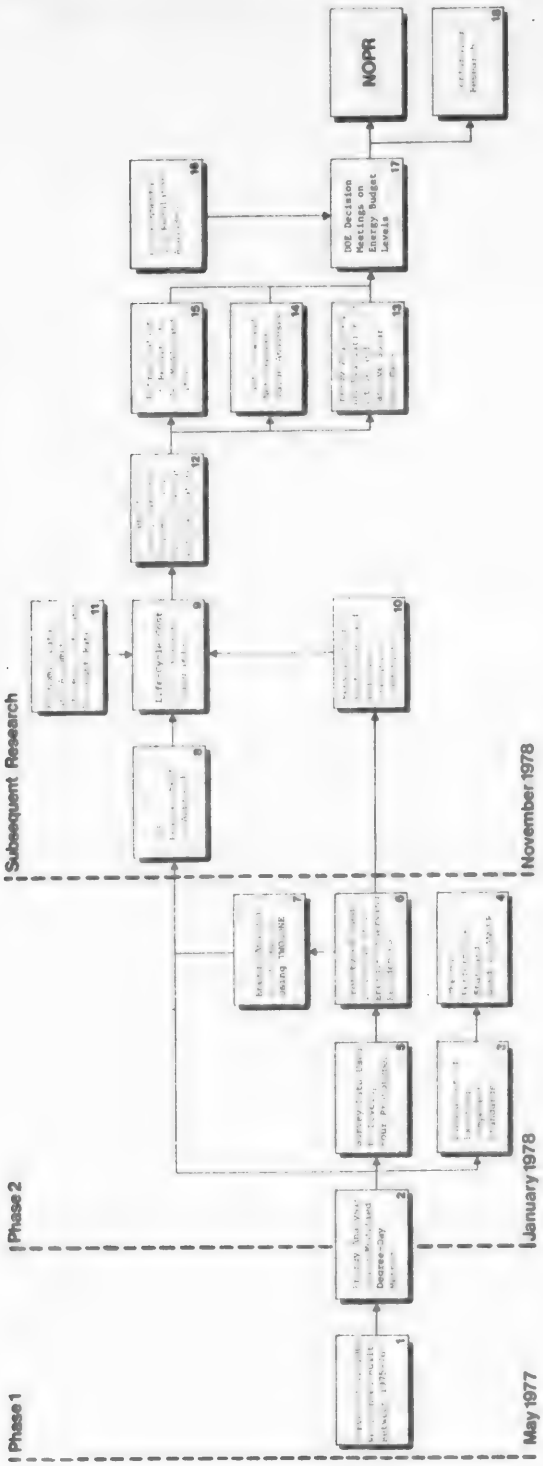

FIGURE 2-4: OVERVIEW OF SINGLE-FAMILY RESIDENTIAL RESEARCH PROGRAM

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A calculation method based on the "degree-day" procedure was used to estimate the energy use for space heating and cooling in the sample buildings (Box 2).[20] Phase 1 produced a data base consisting of building characteristics and estimated energy use for space conditioning for the 120,000-dwelling survey.

In Phase 2 (Boxes 2 through 7), this data base was used to calculate the design energy requirements of the building designs modified for compliance with existing component standards, and to develop more energy efficient residential building designs.

The data base was first used to calculate the design energy requirements of single-family residences [21] designed to meet two component performance energy standards (Box 3): [22] the draft proposed HUD Minimum Property Standards for One- and Two-Family Dwellings (April 1978 version), which specifies thermal transmission requirements for building components, and NAHB's Thermal Performance Guidelines,[23] a cost/benefit approach for calculating levels of thermal protection. The NAHB Thermal Performance Guidelines formed the basis for the residental energy standards approach suggested in the Advance Notice of Proposed Rulemaking (Box 4).

Four prototype designs were prepared from the analysis of the Phase 1 survey data (Box 5). Twenty design teams were selected, based on their experience in designing residences for energy conservation. They were asked to develop "new" residential designs using the prototypes as starting points (Box 6). The designs were intended to result in the maximum possible reduction in design energy requirements, using available energy conservation and passive solar design strategies and technologies.[23] The energy calculation method used to analyze both the prototypes and the 20 "new" designs was a modified version of the TWOZONE computer program (Box 7).[24]

At the end of Phase 2, an evaluation by DOE of the single-family residential research led to a decision to develop and apply a methodology that departed significantly from that used for commercial and multifamily residential buildings (Box 8). The subsequent research developed a life-cycle cost analysis as the basis for the proposed single-family residential Energy Budget Levels. The reasons for departing from the Phase 2 approach were: (1) The energy-conserving designs were not applicable to the mass housing market in the country; and (2) the economic analysis of the four prototypes and the energy conserving designs was not adequate as a basis for a proposed rule. The reasons for the use of a life-cycle cost methodology (Box 8) for the analysis of single-family residential design energy requirements were:

- The life-cycle analyses permitted the use of well-defined economic criteria that have the potential of maximizing the net economic benefits to homeowners and to the Nation, as well as achieving maximum practicable energy conservation.
- Life-cycle cost analyses of energy conservation in single-family residential buildings was facilitated by the data available on the four prototypes based on the Phases 1 and 2 research and by the relative ease of separating the design energy requirements for single-family residences into requirements of the building envelope and of the internal equipment.

The energy analysis program, DOE–2, was used to analyze the design energy requirements of the four prototypes, theoretically placed in ten cities representing a wide range of climatic conditions. The analysis produced a series of life-cycle cost curves. The curves showed the total cost of energy and conservation, valued at the present, plotted against various possible levels of Design Energy Consumption for the building. These curves made it possible to identify the design energy requirements that would result if the minimum total cost to the consumer could be extracted (Box 9). The point on the curve representing the minimum life-cycle cost to the consumer is hereafter referred to as the "nominal" case.

The key assumptions used in deriving the nominal case were as follows:

(1) The only energy conservation measures considered were those currently in common practice in the United States. These included increased levels of insulation in the walls, ceilings, and floors, and the consideration of double and triple glazing in addition to single glazing. These measures were applied in order of declining cost-effectiveness to the four prototypes, which were refined versions of the four prototypes developed in Phase 2 (Box 10).

(2) The conservation measures considered did not require any significant changes in the behavior or level of amenity of the occupant(s). DOE established assumptions of how different building types would be used and operated[25] (Box 10). The cost estimates for energy conservation were those previously developed by the NAHB and used by Oak Ridge National Laboratory (Box 11).

(3) The Energy Information Administration Series B Midterm Price Forecast (44 FR 25369, April 30, 1979) was used (Box 11).

(4) A real (i.e., constant dollar) discount rate of 3% was used, corresponding to an interest rate 3% higher than the inflation rate (Box 11).

The results of the analysis of the life-cycle cost curves were subjected to sensitivity analyses in which key economic parameters were varied, as well as building characteristics and use patterns (Box 12). The economic parameters included: Energy price escalators, costs of energy conservation, and discount rates. The building characteristics included: size, shape, orientation, window area, internal loads (heat produced by appliances and related residential equipment), and infiltration (rate of air exchange through the building envelope). The building characteristics and use patterns included: thermostat management (with and without night setback), use of insulating shutters, and ventilation (with and without windows being opened, when natural ventilation could reduce indoor temperature about as effectively as air-conditioner use). For full details of these life-cycle analyses, sensitivity analyses and their results, see Technical Support Document No. 8, Economic Analysis.

The results of the life-cycle cost studies and related sensitivity analyses were used in three ways: (1) As a starting point for evaluating the economics of active and passive solar heating options, to provide a basis for comparing solar costs to conservation costs in identical single-family residential buildings and climates (Box

[20] The degree-day method consists of calculating heat flows through each component of a building in contact with the outside. The method assumes that the daily energy consumption of a building is proportional to the temperature difference between the mean daily outdoor temperature and a base temperature that represents the point at which no energy is needed for heating and cooling the house. Thus, the method accounts for only daily mean temperatures and does not take into account any interaction between building components (e.g., ceiling and exterior walls).

[21] Multifamily low-rise buildings were examined in Phase 2 and in subsequent research as part of the commercial and multifamily residential analysis efforts.

[22] U.S. Department of Housing and Urban Development and U.S. Department of Energy, "Phase Two Report for the Development of Energy Performance Standards for New Buildings, Task Report: Single Family Dwelliings" (Jan. 1979)

[23] National Association of Home Builders, "Thermal Performance Guidelines for One and Two Family Dwellings" (1977).

[24] Lawrence Berkeley Laboratory, "TWOZONE User's Manual," LBL Report No. 6840 (March 1978).

[25] Technical Support Document No. 5, Standard Building Operating Conditions.

13); (2) as the basis for evaluating the cash flow and net present economic costs and benefits of alternative levels of design energy requirements (Box 14); and (3) as the basis for performing regression analyses of design energy requirements against heating and cooling degree-days so that the results could be applied to 78 SMSA's and cities (Box 15) (see Technical Support Document No. 10, Climate Analysis).

The results of the research program on single-family residential buildings, along with the results of the environmental and regulatory analyses (Box 16), formed the basis for DOE's decisions on the levels of the proposed single-family residential Energy Budget Levels (Box 17). The results of the life-cycle cost studies and related information (Boxes 10, 11, 12, and 13) were particularly important elements in DOE's decisions. Of the four prototypes examined in the analysis, three (single-story, split-level, and two-story) produced very similar results. Therefore, results were used for only two prototypes (attached and detached) in the development of the proposed Energy Budget Levels for single-family residences. Section 3.0 of this preamble and Technical Support Document No. 3, Energy Budget Levels Selection, describe the process followed in selecting the levels of the proposed Energy Budget Levels.

DOE is considering the following subjects for the continuing research effort in support of the final rule for single-family residential buildings (Box 18):

- Expansion of the list of 10 SMSA's and cities to 32 SMSA's and cities for life-cycle cost analyses.
- Continued analysis of the economics and performance of heat pumps.
- Study of additional prototypes, possibly including single-family residences attached on one side only and residences with heated basements.
- Analysis of new, innovative energy conservation concepts, such as the heat recuperator.
- Studies of the life-cycle cost of heating and cooling equipment, and how it interacts with different conservation measures for the building envelope.
- Further analysis of domestic hot water usage data.
- Continued analysis of renewable energy systems, including additional passive solar options and wood burning stoves.
- Reevaluation of life-cycle cost curves using marginal energy prices and updated conservation costs.

A discussion of some of the issues involved in this research is found in Section 2.3.3. DOE is planning continued analysis of issues associated with implementing the Standards for single-family residential buildings. One issue concerns the HUD Minimum Property Standards. A revision of the HUD Minimum Property Standards to achieve equivalency with the Standards is required by Section 252 of the National Energy Conservation Policy Act (Pub. L. 95-619). This subject is addressed in a preliminary report prepared for DOE.[26] The subject is also considered in the discussion of single-family residential design energy requirements found in Section 3.3 of this preamble.

2.2.3 Mobile Homes

DOE has not included mobile homes in the proposed rule at this time. The research that is necessary and appropriate to propose a mobile home energy performance standard has not been completed. DOE is working with HUD to complete that research. The following discussion presents past research efforts and the thrust of expected future studies.

The research to date has been conducted in three phases. Phase 1 consisted of surveying a sample of mobile homes that represented over 160,000 units. The sample was analyzed, using the same calculation method that was used in Phase 1 for single-family residences, to arrive at a baseline of energy requirements for space heating and cooling of mobile homes (see discussion in Section 2.2.2).[27]

In Phase 2, mobile home prototypes were developed (two single-wide and two double-wide units), based upon the Phase 1 data. Then, the prototypes were used to develope new mobile home designs that approached the maximum technically feasible reductions in design energy requirements. The resulting energy savings of the new designs were calculated using a proprietary computerized calculation method.[28]

The energy analysis indicated that all four original prototypes met the energy requirements of the HUD Mobile Home Construction and Safety Standards and that significant energy savings were possible with the maximum technically feasible designs.[29]

The term "maximum technically feasible design" (MTFD) was defined to mean the design resulting in a mobile home that required the least possible energy to heat and cool, yet:

- Required no change in owner lifestyle.
- Could be mass produced.
- Met reasonable requirements for life and safety.
- Could be transported over highways within existing regulations.
- Was sized to fit prevailing mobile home park space limitations.

The Phase 2 analysis for mobile homes was, like the analysis for other building classifications, primarily an energy analysis. A detailed analysis was conducted of changes in construction costs from the prototypes to the following two sets of maximum technically feasible designs: (1) Factory installed conservation options only, or (2) factory plus site installed conservation options.[30] However, no economic analysis was conducted on the change in first cost to the mobile home owner compared with the changes in the monthly costs of mortgage and fuel combined.

DOE considers a careful cost-benefit analysis to be especially important for a mobile home standard. These dwellings are at the low end of the cost spectrum for housing. In many cases, mobile homes provide the only affordable option for new homes for many citizens. Therefore, any new regulation in energy conservation should not interfere with the ability of potential mobile home owners to:

- Finance the down payment for a mobile home (a potential consequence of a major increase in first cost of manufacturing).
- Pay for the combined monthly mortgage costs and monthly fuel costs (fuel costs would decrease relatively, while mortgage costs might increase).

Therefore, during the third phase of the research, DOE conducted an initial life-cycle cost analysis on the most prevalent single-wide prototype. The analysis used the existing energy data developed from Phase 2 and developed additional cost data for each energy conservation option considered.[31]

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[26] Lawrence Berkeley Laboratory, "Residential Energy Performance Standards: Comparison of HUD s Minimum Property Standard and DOE's Proposed Standard," draft report (Report No. LBL-9817) (October 1979).

[27] See footnote 19.

[28] The T. R. Arnold & Associates (TRAA) computer program is based on the HUD Mobile Home Construction and Safety Standards, Subpart F, with guidance from ASHRAE manuals and the manual, "Mobile Home Heating and Cooling Load Calculations for Determining Compliance with the Energy Conservation Criteria of the Standard for Mobile Homes," 501 BM, 1976, published by the National Fire Protection Association (NFPA). TRAA derived thermal transfer coefficients from ASHRAE and NFPA 501 BM using hand calculations.

[29] T. R. Arnold Associates, "Development of Building Energy Performance Standards for Mobile Homes" (June 1978).

[30] Steven Winters Associates, Inc., "Cost Analysis of Mobile Homes" (November 1978).

[31] U.S. Department of Housing and Urban Development and the U.S. Department of Energy, "Phase 2 Report for Development of Building Energy Performance Standards: Task Report/Mobile Homes" (June 1979).

The results of this life-cycle cost analysis indicated that additional cost-beneficial energy conservation strategies existed which would result in reductions in both energy use and life-cycle costs. However, the results were limited for the following reasons:

- The energy calculation method did not permit an accurate analysis of certain conservation options.
- The procedure for deriving energy results for such options was not fully documented in the Phase 2 reserach.
- The energy savings for some conservation strategies could not be disaggregated in order of cost-effectiveness.
- An analysis of enough different sequences of cost analysis strategies was not done to identify a life-cycle minimum range.

For these reasons, DOE determined that the research to date was not sufficient for proposing a standard for mobile homes. To be responsive to the economic requirements of potential mobile home owners, a full and detailed cost-benefit analysis should be completed. This is currently planned and will provide a sound economic basis for the selection in the future of appropriate levels of Standards for mobile homes.

2.3 Additional Reserach Affecting Energy Budget Levels

The discussions in Sections 2.1 and 2.2 address the research program formulated to assist DOE in selecting the proposed Energy Budget Levels. As noted, the commercial and multifamily residential buildings analysis relied heavily on a detailed statistical analysis of the designs and redesigns of a number of building types in different climate regions. The analysis of single-family residential buildings used the results of a major survey to develop prototypes, which were then analyzed on a life-cycle cost basis. The impacts of the proposed standards for single-family residential, commercial and multifamily residential buildings were assessed using economic modeling techniques which projected energy demand and direct and indirect economic costs and benefits of alternative levels of proposed Energy Budget Levels. Environmental and regulatory analyses also provided relevant information.

This section of the preamble extends this discussion to three additional issues, each of which will require substantial research before the results can be incorporated into the Standards. The issues are: (1) The health effects of possible degradation in indoor air quality that can result from reducing air infiltration rates in single-family residential buildings and ventilation rates in commercial and multifamily residential buildings; (2) the potential for a life-cycle cost analysis of commercial and multifamily residential buildings, to identify new cost-effective means of significantly reducing their design energy requirements; and (3) a number of issues affecting single-family residential design energy requirements, including the potential contribution of new and innovative conservation measures.

The first issue requires research in three areas: (1) Measurement of air infiltration rates; (2) analysis of the relationship between building design, building construction, air infiltration rates, and concentrations of indoor air pollutants; and (3) health and other effects of indoor air pollutants.

DOE believes that the proposed Standards have been formulated in a manner that does not adversely affect indoor air quality, as discussed in the next Section.

The second and third issues require both continuing research efforts and commercial experience with new approaches to energy conservation.

DOE is supporting work in all of these areas. To the extent that new data are available prior to the final rulemaking, DOE will consider that data in selecting the final Energy Budget Levels. However, DOE anticipates that the ongoing research in these areas will be of particular use in future updates of the Standards.

2.3.1 Environmental Issues

In setting the proposed Standards, DOE was specifically concerned about the issue of indoor air quality.[22] DOE recognized the potential for conflict between energy conservation objectives, which would reduce infiltration and ventilation rates in buildings, and the adverse impacts of indoor air pollutants on the public health and welfare, which can be mitigated by increasing the infiltration and ventilation rates of buildings. Because of uncertainity in (1) data on and measurement of air infiltration rates in buildings, (2) the relationship between infiltration and ventilation rates of buildings and the concentrations of indoor air pollutants, and (3) the health effects of different levels of indoor air pollutants, DOE has taken a cautions approach in dealing with this issue.

DOE's basic approach has been to design the Standards so that no change is likely to occur in the levels of indoor air pollutants of buildings constructed after the Standards are implemented. The manner of achieving this objective is discussed separately below for (1) commercial and multifamily residential buildings, and (2) single-family residential buildings.

The Design Energy Consumption of a commercial or multi-family residential building is evaluated using the ventilation rates required by local health codes. DOE anticipates no change in local health codes as a result of the Standards. Therefore, the Standards are not expected to either reduce ventilation rates for commercial and multi-family residential buildings or diminish indoor air quality in these buildings.

In developing the proposed Energy Budget Levels for single-family residential buildings, DOE used a value of 0.6 air changes per hour on an average winter day, which was used to calculate infiltration rates for all such buildings.[23] The same value is included in the Standard Evaluation Technique (discussed in Section 4.0 of this preamble) for evaluating the Design Energy Consumption of a single-family residential building. No credit or penalty is currently given for the design of a building with a lower or higher infiltration rate. Because the Standards do not give credit for designs that reflect low rates of infiltration, they are expected to have no effect on the indoor air quality of single-family residential buildings.

DOE is presently developing approaches to evaluate the effects of different measures to reduce infiltration in single-family residential building designs (e.g., the use of continuous polyethylene vapor barriers, weather stripping on windows, and caulked sills). These measures could reduce the average air infiltration rate to 0.1 air change per hour in a mild climate and 0.2 air change per hour in a colder climate. If such measures had been considered and included in the Standard Evaluation Technique, then the Standards would impact indoor air quality by giving credit to a design with low air infiltration rates.

DOE welcomes public comment on this issue, specifically with regard to: (1) The desirability of the present approach, in which no credit is given for reductions in the rate of air infiltration and no adverse impact on indoor air quality is expected, and (2) the feasibility and advisability of

[22] This subject is addressed in Technical Support Document No. 7, Draft Environmental Impact Statement and in Technical Support Document No. 3, Energy Budget Levels Selection.

[23] The treatment of air infiltration rates in the evaluation technique for single-family residential buildings is discussed in Technical Support Document No. 1, The Standard Evaluation Technique.

developing an approach that evaluates and gives credit for reductions in air infiltration in single-family residential buildings.

2.3.2 Life-Cycle Cost Analyses of Commercial Buildings

The Phases 1 and 2 research effort on commercial buildings was based primarily on (1) a statistical analysis of a large sample of buildings for which construction began in 1975–1976, and (2) the simulation of the design energy requirements of the energy conserving redesigns of a selected subsample of those buildings. DOE has extended this research to include a preliminary analysis of the life-cycle costs of three commercial office buildings (selected from the Phase 2 sample for their typical characteristics) in which many different energy conserving measures are integrated into the designs of the buildings. The general approach to the life-cycle cost analysis of commercial buildings is similar to that performed on single-family residential buildings. However, because many conservation measures for commercial buildings are an integral part of the building design and equipment configuration, the life-cycle cost approach is more complex than for single-family residential buildings.[34]

The results of the preliminary life-cycle cost analysis of commercial office buildings indicated a potential for significant reductions in Design Energy Budgets below those derived from the redesign studies.[35] Two design strategies appeared especially promising: (1) the introduction of a "deadband" thermostatic control system, and (2) automatic control systems for incorporating daylighting into building design.[36]

The life-cycle cost analysis of energy-conserving designs of commercial buildings appears to be promising. DOE intends to continue this analysis using commercial building prototypes yet to be developed. The anticipated results will provide information about the conservation investment and the value of energy savings of specific energy conservation and renewable energy design strategies. If this research shows that more stringent conservation measures are technically, economically, and commercially viable, DOE may amend the Standards and decrease the Energy Budget Levels for such building classifications.

DOE invites public comment on these matters, particularly: (1) The desirability and feasibility of applying a life-cycle cost approach to commercial buildings, and (2) the description and evaluation (in terms of successes and failures) of innovative energy conservation strategies for commercial buildings.

2.3.3 Issues Affecting the Energy Budget Levels for Single-Family Residential Buildings

The continuing research activities for single-family residences are discussed at the end of Section 2.2.2. The purpose of this section is to elaborate on selected research issues that can affect selection of the Energy Budget Levels. The issues addressed are: (1) Domestic hot water usage data, (2) the practicability and availability of new and innovative energy conservation measures for single-family residential buildings, (3) renewable energy resources, (4) masonry construction, and (5) extensions to the life-cycle costing methodology for energy conserving measures used in single-family residences. When applicable, the discussion includes comments received in response to the Advance Notice of Proposed Rulemaking, ANOPR, and an explanation of DOE's ongoing research effort.

Domestic Hot Water Usage

The proposed Energy Budget Levels for single-family residences contain three energy components: Space heating, space cooling, and domestic hot water heating. The proposed Energy Budget Levels for space heating and cooling vary to reflect regional changes in climate conditions; they also apply to each square foot of gross area of the residence, regardless of the size of the residence. (See Technical Support Document No. 8 Economic Analysis)

On the other hand, the proposed Energy Budget Levels (a separate level for each of the different nonrenewable fuels) for domestic hot water heating are fixed quantities for all regions of the country; also, they are based on an average number of occupants per residence and do not vary with the size of the residence.

The proposed Energy Budget Levels for domestic hot water heating have been included for single-family residences because:

- The contribution of domestic hot water to the Design Energy Consumption is large, on the order of 50% in a moderate climate (the percentage is smaller in colder climates and larger in warmer climates).
- The approach provides additional encouragement for the use of solar domestic hot water heaters, as discussed below.

(See Section 3.3 of this preamble and Appendix I of the proposed rule for a further description of the inclusion of domestic hot water in single-family residential Design Energy Budgets.)

There are two issues pertinent to domestic hot water usage that DOE intends to address in continuing research:

- Improvement of the estimation techniques to establish the average level of domestic hot water usage.
- Application of life-cycle costing techniques to evaluate economic tradeoffs between increases in the efficiency of domestic hot water heaters and energy conservation measures in the building envelope.

DOE is interested in information regarding the degree to which the inclusion of domestic hot water in the Design Energy Budget will encourage the use of solar domestic hot water heaters.

Public comments on these and other issues relative to domestic hot water heating will be useful to DOE in developing the final rule.

New and Innovative Energy Conservation Options

As described in Section 2.2.2, in evaluating and selecting the proposed Energy Budget Levels for single-family residences, DOE considered only those conservation measures that are in common practice. DOE is particularly interested in the availability, performance and costs of the following measures, which could be used in single-family residences:

- 2 x 6 studs (as a means of increasing the thickness of insulation of exterior walls) or two rows of 2 x 4 studs.
- Triple glazing, achieved through the use of either storm windows with double glazing or windows with three panes of glass.
- Ceiling insulation with thermal resistance of greater than R–38.
- Measures to reduce air infiltration and ways to reduce indoor air pollution with low infiltration levels.
- Different approaches to passive solar energy design strategies.
- Any other innovative techniques that might significantly reduce energy requirements in single-family residential buildings, especially those techniques that might have wide applicability in various parts of the Nation.

[34] Federal Energy Management and Planning Programs: Proposed Methodology and Procedures for Life Cycle Cost Analysis of Federal Buildings. 44 FR 2536 (April 30, 1979).

[35] AIA Research Corporation, "Life Cycle Cost Study of Commercial Buildings" (draft) (Oct. 1979).

[36] Daylighting involves the use of photocell controls to automatically reduce artificial lighting when sufficient light is available from natural light sources. These controls are generally combined with building design strategies that provide access to appropriate levels and quality of light where needed.

Information submitted to DOE will be considered in developing the final rule, as well as in evaluating the possibilities and research priorities for updating the Standards.

Renewable Energy Sources: Effects On Energy Budget Levels

The treatment of renewable energy sources for use in buildings has played a major role in the development of the proposed Standards. To date, this has occurred through an analysis of the economic viability of active and passive solar space heating systems and through the decision to include domestic hot water heating as a part of the proposed Energy Budget Levels, which would permit the designer greater flexibility in selecting conservation measures if active solar domestic hot water heating is incorporated into the design. DOE also intends to encourage solar energy options by describing and explaining their use in a Manual of Recommended Practice.[37] Furthermore, as energy prices increase and the cost of renewable energy systems decline, the Standards are expected to be updated to reflect the inclusion of renewable energy systems in the package of options contributing to the life-cycle costs used to establish the Energy Budget Levels.

Masonry Construction

DOE has analyzed the thermal characteristics of masonry walls for the purpose of deciding if a single-family residential prototype with masonry walls should have an Energy Budget Level different from the other prototypes.

This study, as well as analyses completed for HUD, has shown that residences with exterior masonry walls use only slightly less energy than residences with frame walls.[38] Since no significant differences were found, DOE proposes to give masonry construction the same Energy Budget Levels as frame residences. Residences with exterior masonry walls can meet the Design Energy Budgets either by using available, cost-effective insulation strategies or by reducing energy losses through other components (e.g., windows, ceilings, floors).[39]

DOE is unaware of data or other documentation to support a special approach for masonry construction. If such information is submitted to DOE, it will be considered in the development of the final rule.

Continuing analysis of masonry construction will focus on: (1) Reviewing methodologies and results of energy simulations of masonry buildings, and (2) analyzing different configurations of insulation for masonry walls.

Extensions to Single-Family Residential Life-Cycle Costing Methodology

There are at least two main issues of the single-family residential life-cycle cost analysis that affect the Energy Budget Levels: (1) Extension of the approach to include efficiency improvements in building heating and cooling equipment, as well as energy conservation measures for the shell of the building, and (2) refinement of the economic parameters used in the analysis.

DOE presently intends to extend the single-family residential life-cycle cost analysis to include certain residential equipment efficiencies. Included will be an analysis of the cost-effectiveness of improving the efficiency of furnaces, air-conditioners, heat pumps and domestic hot water heaters. DOE will then be able to compare investments in more efficient equipment with investments in conservation options for the design of the building shell.

The economic parameters used in the life-cycle cost analysis may change in the following ways, depending on the availability of reliable information: (1) The fuel price projections may be changed to use prices based on replacement energy costs (e.g., costs of producing and delivering an additional quantity of energy), and (2) the costs of the energy conservation options will be based on the best information available at the time of the final rule.

Comments on these and other possible changes to the life-cycle cost approach are requested.

2.4 Research Affecting the Format of the Energy Budget Levels

The research program described thus far was performed primarily to assist DOE in determining the appropriate Energy Budget Levels. This has included building surveys, building design experiments, the analysis of prototypical buildings, and environmental and economic analyses.

The research program described below was necessary to establish a format to be used in formulating the proposed Energy Budget Levels.

The research examined a number of areas:

- Weighting factors for different fuel types, to reflect the relative value to the Nation of conserving different fuels.
- Appropriate incentives for the use of renewable energy resources, through the application of the Design Energy Budget to a building design.
- Building design classifications, to reflect the varying energy requirements of buildings designed to fulfill different purposes.
- Standard Building Operating Conditions, to provide consistent conditions under which the Design Energy Budgets of different building designs are evaluated.
- A climate selection procedure to reflect the impact of climatic variations on the energy requirements of building designs.
- A unit of measurement for the Design Energy Budgets.

These factors are discussed in the following sections. (Also, see Technical Support Document No. 3, Energy Budget Levels Selection.)

The approach taken in the following sections includes, as appropriate, an explanation of the issue, a summary of comments received on that issue in response to the ANOPR, the status of DOE's research and analysis of the issue, and the reasons for any decisions that have been made for this proposed rule. The commentary on the responses to the ANOPR is emphasized in several sections because of the interest that the respondents showed in that particular issue.

2.4.1 Weighting Factors

Summary

DOE considered three alternatives for expressing the proposed Energy Budget Levels in terms of weights for each type of nonrenewable fuel used (natural gas, oil and electricity):

- The use of Energy Budget Levels expressed in terms of the energy content of the fuel delivered to the building site, with all weights set equal to one (equivalent to viewing design energy from the perspective of the building boundary).
- The use of Resource Utilization Factors (RUF's) and Resource Impact Factors (RIF's) to reflect, respectively, the energy consumption to the Nation of providing energy to a building site, starting at the energy source, and the social impacts of using different fuel types.
- Weighting factors based on the relative "value" of the different fuels to

[37] "Manual of Recommended Practice" is a document which gives examples of building designs which meet or exceed the requirements of the Standards and explains why such designs are appropriate for particular environmental conditions, building classifications and building uses.

[38] A summary of analysis results to date is contained in Technical Support Document No. 8, Economic Analysis.

[39] The proposed rule does specify that interior masonry and any other construction technique that may provide passive solar gains to the house be given appropriate credit through the use of the Standard Evaluation Technique (discussed in Section 4.0 of the Preamble).

the Nation, expressed in terms of (1) fuel prices, and (2) explicit national policy determinations of non-market values associated with specific fuel types.

For this proposed rule, the use of the first two alternatives has been rejected by DOE in favor of weighting factors based on DOE's assessment of the value of different fuel types to the Nation. This section discusses the past approaches considered, explains the reasons for DOE's decision on weighting factors, and discusses the effects that the use of weighting factors is likely to have.

Approach Originally Suggested in the ANOPR

In the ANOPR, DOE suggested Design Energy Budgets that reflected energy consumed from the source (e.g., coal mine, oil well, gas well) to the building site, instead of energy consumed at the site, using multipliers called Resource Utilization Factors and Resource Impact Factors. RUF's are multipliers of building boundary energy that convert the quantity of energy consumed at the building site to an equivalent amount of energy from its source; i.e., to account for not only the Btu's of energy used within the building but also the energy consumed in refining, converting, and transporting raw energy into delivered energy at the building site.

Resource Impact Factors are multipliers of building boundary energy to reflect differing social values to the Nation of using different types of fuel.

In the ANOPR, DOE expressed the suggested Design Energy Budgets in terms of RUF's. All RIF's were set equal to one, pending the outcome of research to develop an analytical basis for deriving them. Thus, the ANOPR presented a framework for expressing the Design Energy Budgets that could account for all losses of energy from the source as converted into useful energy for space conditioning and other uses in buildings. The ANOPR suggested the use of RUF's and RIF's based on national averages.

Difficulties With the Approach Taken in the ANOPR

Sixty-three comments addressed the issue of RIF's/RUF's. Three views generally were taken: (1) Comments favoring the use of RUF's; (2) comments opposing the use of RUF's, or suggesting that the RUF's be set equal to one for all fuels (i.e., expressing the Design Energy Budgets as the sum of the energy content of the fuels delivered to the building site); or (3) comments urging consideration of RIF's, along with RUF's.

Most of the proponents of RUF's indicated that their use was simple enough for practical application, that they are typical engineering solutions to typical engineering problems. These comments went on to suggest various refinements to the Design Energy Budgets as outlined in the ANOPR. Three comments advocated the use of local or regional, as opposed to national, RUF's. Three other comments observed that RUF's should be based on actual records and projections prepared by the local utility serving the building in question.

Opponents of RUF's and RIF's contended that it was the intent of Congress to limit the scope of the Standards to site-based energy only. Seven comments specifically observed that the national average RUF's suggested in the ANOPR would encourage the continued use of natural gas and oil, contrary to the Administration's policies and national interests. Another commented that RUF's did not account for utility cogeneration possibilities. One comment criticized RUF's for not considering all energy related factors. Finally, many opponents of RUF's suggested that their use penalized all types of electrical use.

The third group of comments addressed the use of RIF's in conjunction with RUF's. They suggested that using RUF's alone would create a distortion and that the use of RIF's and RUF's together would account for differences in social considerations involved in the use of different fuels. Several comments suggested ways in which RIF's might be determined: (1) Through use of a fuel reserve index; (2) through calculation of pounds of atmospheric pollutants produced per unit of energy converted; and (3) through consideration of externalities (i.e., adverse impacts not accounted for in the pricing system). Six comments further observed that a full complement of RIF's/RUF's should be developed for all types of fuels and energy resources, even to the point of differentiation among grades of coal and petroleum distillates.

Three commentators suggested not using RUF's without RIF's. One comment suggested that RIF's were a good approach but were impractical at this time.

DOE's Decisions on Weighting Factors

Consideration of the public comments, along with the results of DOE's research program, led to renewed consideration of alternatives to RIF's and RUF's.

As noted, one alternative was to express the Design Energy Budgets in terms of Btu's of energy used at the building boundary; that is, using weights equal to one for all forms of energy. Design Energy Budgets expressed in terms of energy use at the building boundary are simple to comprehend since they are expressed in terms of metered energy into the building, a concept with which designers and builders are familiar. This approach, however, ignores energy losses in the conversion of an energy resource into a useful energy form (e.g., synthetic fuels and electricity, whose inefficiencies are concentrated in that part of the fuel cycle upstream of the building boundary).

DOE decided to reject both the use of RUF's and RIF's and the use of weights that would effectively value all forms of energy equally at the building line.

DOE concluded that both approaches would be inadequate because of their inability to reflect the relative value to the Nation of conserving different nonrenewable fuels. Both would weigh the consumption of fuels, but neither would take adequate account of social or policy considerations. Thus, the scarcity value of fuel would be ignored, as would the true cost to the Nation of consuming certain fuels. Also, such weights would be unable to reflect such important concerns as the national security cost inherent in becoming more dependent on imported fuels.

DOE recognizes the potential of a combined RUF/RIF approach to overcome the inadequacies mentioned above. However, DOE has reservations about the combined RUF/RIF approach because of its complexity and its difficulty in making explicit the relative importance of the various factors affecting the selection and presentation of a Design Energy Budget.

Consequently, DOE has developed an approach using weighting factors that explicitly account for the cost of fuels and the value to the Nation of conserving different fuels. The use of the proposed weighting factors can help create an environment in which building designers are encouraged to make design tradeoffs and fuel choices that reflect how the Nation values various forms of energy.

The general approach starts with the market prices of the various fuels, where a portion of their relative values is reflected. An important issue is whether to derive the factors using average prices or replacement costs. (Average prices of energy are based on the existing mix of old and new energy sources; replacement costs are the costs of new energy sources such as a new powerplant.) DOE believes that replacement costs are the most appropriate indicator of the cost to the Nation of producing new sources of energy for new buildings, and that replacement costs are preferable for the

development of weighting factors. However, since acceptable estimates of such costs were not available in time for this proposed rule, average price forecasts were used to derive the proposed weighting factors.

Another issue is whether to include a premium for oil and gas, to recognize in the same way as the Powerplant and Industrial Fuel Use Act of 1977 (FUA) (Pub. L. 95–620) that saving a barrel of oil is worth more to the Nation than its price reflects. Consistent with FUA, DOE has decided to add a premium of $1.29 per million Btu to the oil and gas prices to derive the weighting factors. (See Technical Support Document No. 4, Weighting Factors.)

A final issue concerns the aggregation of fuel mix across geographic regions and building types. For purposes of this proposed rule, DOE prescribed one set of weighting factors for all commercial and multifamily residential building types and another set of weighting factors for all single-family residential buildings. The weighting factors were national averages and were the same for all geographic regions. Insufficient regional data was available to develop regional weighting factors. For commercial and multifamily residential buildings, the weighting factors were applied by using an average mix of fuels for the buildings, which varied from region to region of the country. The regional fuel mix averages used reflect the generally larger percentage of electrical energy used in the southern areas of the country. Should the ongoing research identify serious inequities in this approach, appropriate modifications will be considered for the final rule.

Until the ongoing research related to weighting factors and replacement costs is complete, weighting factors based on average prices are being used. These estimates are calculated from relative national average prices for oil and electricity projected for 1985 using the mid-term forecast published in the April 30, 1977, **Federal Register.**[40] These estimates are chosen to be consistent with the forecast used in the economic analysis (see Technical Support Document No. 8, Economic Analysis).

Technical Support Document No. 4, Weighting Factors, describes the research and derivation of the weighting factors proposed by DOE. The following proposed weighting factors are used:

	Natural Gas	Oil	Electricity
Single-family residential	1	1.22	2.79
Commercial and multi-family residential	1	1.20	[illegible]

The Effect of Using the Proposed Weighting Factors

The weighting factors are used as a way of expressing the Design Energy Budget of a building design. Application of the weighting factors is straightforward. The designer first calculates the energy requirements by fuel type. The energy requirement for each fuel type, expressed in MBtu/sq. ft./yr, is then multiplied by the appropriate weighting factor for the fuel type. These weighting figures are then summed over all fuels to arrive at the Design Energy Consumption of the building. The value of the Design Energy Consumption must be less than or equal to the Design Energy Budget (determined in accordance with Appendix I of the proposed rule) for the building design to be in compliance with the Standards.

Table 2–1 illustrates Energy Budget Levels for commercial and multifamily residential buildings for eight cities in the Nation.[41] These Energy Budget Levels are expressed in terms of weighted MBtu/sq. ft./ yr, using the values of the weighting factors presented in Section 2.4.1. The Standard Evaluation Technique (Section 4.0) specifies that the weighting factors used to establish the Design Energy Budget must also be used in calculating the Design Energy Consumption.

Many designers are accustomed to thinking about energy use in terms of the energy required at the building boundary. Because the Energy Budget Levels in Table 2–1 are calculated using weighting factors, the values may not be familiar. For this reason, three sets of illustrative Energy Budget Levels are presented in Table 2–2: the first set is in units of MBtu/sq. ft./yr of energy at the building or site, the second set, in bold print, is in MBtu/sq. ft./yr of energy using weighting factors, and the third set is in MBtu/sq. ft./yr of energy at the source (i.e., RUF-weighted).

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[40] Technical Support Document No. 3, Energy Budget Levels Selection, contains tables showing values that might have been selected for the Energy Budget Levels if it has been decided to express the Energy Budget Levels at the building boundary or in terms of RUF's and RIF's.

[41] The Energy Budget Levels in the proposed Standards are presented in Appendix I, for commercial, multifamily residential and single-family residential buildings in 78 SMSA's and cities.

TABLE 2-1: ILLUSTRATIVE ENERGY BUDGET LEVELS FOR COMMERCIAL BUILDINGS FOR EIGHT CITIES (in MBtu/sq. ft./yr)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High-Rise	Multifamily Low-Rise	Nursing Home	Office, Large	Office, Small	School, Elementary	School, Secondary	Shopping Center	Store	Theater/Auditorium	Warehouse
Minnesota	Minneapolis	142	109	144	335	180	140	110	175	123	117	122	138	198	155	157	93
Missouri	St. Louis	133	110	136	353	175	128	112	163	119	109	105	128	192	150	149	72
District of Columbia	Washington	127	107	129	353	169	120	109	164	115	104	96	121	185	144	142	63
Florida	Miami	152	142	161	406	203	133	147	201	140	125	103	141	219	179	178	41
Texas	Dallas	131	116	136	358	175	119	119	171	120	107	94	124	190	152	150	50
California	San Diego	114	103	117	364	158	104	106	153	107	92	75	107	172	134	128	40
Oregon	Portland	119	98	120	353	161	116	99	154	108	97	91	115	176	135	131	66
Massachusetts	Boston	125	101	126	338	165	121	102	159	111	102	99	121	181	140	139	72

TABLE 2-2: ILLUSTRATIVE COMPARISON OF WEIGHTED COMMERCIAL ENERGY BUDGET LEVELS WITH SITE- AND SOURCE-BASED ENERGY BUDGET LEVELS (in MBtu/sq. ft./yr)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High Rise	Multifamily Low Rise	Nursing Home	Office Large	Office Small	School Elementary	School Secondary	Shopping Center	Store	Theater/Auditorium	Warehouse
Minnesota	Minneapolis	58 142 156	45 109 120	59 144 158	140 335 370	74 180 199	58 140 154	45 110 122	72 175 193	51 123 135	48 117 129	50 122 134	57 138 152	82 198 218	64 155 171	65 157 173	38 93 103
Missouri	St Louis	52 133 146	43 110 121	53 136 149	140 353 388	68 175 192	50 128 140	44 112 123	66 163 179	47 119 131	43 109 120	41 105 115	50 128 141	75 192 210	59 150 165	58 149 164	28 72 79
District of Columbia	Washington	50 127 139	42 107 117	51 129 142	140 353 388	66 169 186	47 120 132	43 109 120	64 164 180	45 115 126	41 104 114	37 96 105	47 121 133	72 185 203	56 144 159	56 142 156	24 63 69
Florida	Miami	52 152 168	48 142 157	55 161 177	140 406 447	69 203 224	45 133 147	50 147 162	68 201 222	48 140 155	43 125 138	35 103 113	48 141 156	74 219 241	61 179 197	60 178 196	14 41 45
Texas	Dallas	51 131 145	45 116 128	52 136 150	140 358 395	67 175 193	46 119 132	46 119 132	66 171 189	46 120 132	41 107 119	36 94 103	48 124 136	73 190 209	58 152 168	40 150 166	19 50 55
California	San Diego	43 114 126	39 103 114	44 117 129	140 364 403	60 158 175	39 104 115	40 106 117	58 153 169	41 107 119	35 92 102	28 75 83	41 107 119	65 172 190	51 134 149	49 128 142	15 40 44
Oregon	Portland	47 119 131	38 98 107	47 120 131	140 353 388	63 161 177	45 116 127	39 99 108	60 154 169	42 108 119	38 97 106	35 91 100	45 115 126	69 176 194	53 135 148	51 131 144	26 66 73
Massachusetts	Boston	51 125 137	41 101 111	52 126 139	140 338 371	67 165 181	50 121 133	42 102 112	65 159 174	45 111 122	42 102 112	41 99 109	49 121 133	74 181 198	57 140 154	57 139 152	30 72 79

58 Building line design energy

142 Weighted Energy Budget Level

156 RUF-Weighted design energy requirement

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The implication of using weighting factors was clarified by examining the effects of the chosen weighting factors on the capability of a building design to meet Standards expressed, for example, in terms of RUF's or in terms of site weighted units. The Phase 2 commercial and multifamily residential redesign buildings were reviewed to determine which ones would meet the Standards (set at about the same level of stringency) expressed in terms of various weighting schemes. The results of that examination revealed that most of the basically well designed buildings that would be in compliance with a Design Energy Budget where all weights were equal to 1.0 (i.e., site-based) would also be in compliance with a Design Energy Budget where the weighting factors were derived by DOE as noted above, and with RUF's as well.

Even though the weighting factors are not likely to significantly affect a building design that is in compliance with the proposed Standards, they will be important in influencing a designer to save one or another type of fuel when faced with that option during the design process. As discussed in Technical Support Document No. 4, Weighting Factors, the use of weighting factors encourages designers to conserve energy in a cost-effective manner (or in a manner consistent with the value to the Nation of saving different nonrenewable fuels). Thus, if a designer must reduce the energy requirements of a building design by a few MBtu's/sq. ft./yr to achieve compliance with the Standards, he is more likely to reduce gas if site-based weighting factors are used and more likely to reduce electricity if the value-based weighing factors given in this proposed rule are used (all other things being equal).

In short, the use of DOE's proposed weighting factors will not significantly affect the overall energy savings expected to be achieved by the Standards. The same overall (source) energy savings could be achieved using Design Energy Budgets expressed in terms of any weighting factors; the selection of the Energy Budget Levels is separate from the selection of the weighting factors. However, the choice of weighting factors will influence the mix of fuel types saved.

Request for Public Comment

Public comment is sought on the approach taken to establish weighting factors for the different fuels. There are four issues where public comment would be especially useful to DOE:

- The use of average prices instead of replacement costs in setting weighting factors.
- The use of national, regional, state, or local prices in setting weighting factors.
- The appropriateness of the choice of applying DOE's price premium for gas and oil in setting weighting factors.
- The overall utility of the weighting factor approach as presently proposed by DOE.

For additional details on the derivation and use of weighting factors, see Technical Support Document No. 4, Weighting Factors.

2.4.2 Renewable Sources of Energy

This section addresses the issue of how the proposed rule may increase the use of nondepletable sources of energy.

Nondepletable energy technologies include active and passive solar systems, certain systems for generating electricity, and systems using biomass for fuel. Such systems may provide energy for space heating and domestic hot water, space cooling, and natural lighting.

In this section, five renewable energy systems are discussed: active solar space heating; passive solar space heating; active solar domestic hot water heating; natural lighting; and wood burning stoves. Other renewable energy systems for which there are ongoing research, design and development activities, include: photovoltaics; wind energy conversion; biomass conversion; and active or passive solar cooling. Such systems were not considered for this proposed rule.

A part of DOE's research program in support of the Standards has been an ongoing analysis of the role of solar energy systems as a source of heat for use in buildings. At the present time, the main types of economically competitive renewable energy systems that can supply a building with heat for space conditioning and domestic hot water are: active solar energy systems, passive solar features in the designs of buildings, and wood burning stoves. DOE commissioned research and analysis to assess the effects of the proposed Standards on the use of active and passive solar energy systems in building designs. Work on wood burning stoves in conjunction with the Standards is just beginning. The results of the solar studies are found in Technical Support Document No. 9, Passive and Active Solar Heating Analysis, and in Appendix A of Technical Suppport Document No. 8, Economic Analysis. Although these studies are ongoing and have not arrived at final results, DOE is able to indicate in a general way the main thrust of the impact of its proposed rule on the use of renewable resources in buildings.

Research Results

A number of general conclusions about the potential role of solar energy systems in buildings can be derived from the analysis reported in Technical Support Document No. 9, Active and Passive Solar Heating Analysis, and from a wide arange of other analyses underway in DOE's research, development and commercialization program for active and passive solar heating and cooling of buildings. The conclusions are:

- Passive and active solar energy systems do provide a viable option for achieving the Design Energy Budgets of single-family residential buildings.
- For specific buildings using different fuel types in various climates, there is a mix of conventional conservation techniques passive solar, and active solar systems that will maximize the economic and energy goals of the space conditioning system.
- Even when passive and active solar energy systems achieve an economic advantage over competing space heating systems (in terms of life-cycle cost to the homeowner), the incentive for builders to incorporate solar systems may be lacking. This is especially likely where the solar systems involve greater first costs than other ways of supplying heat or reducing demand for space heating. While significant energy savings can be realized from the use of active and passive solar energy systems, the rate at which builders incorporate solar design options will depend on a wide range of economic, institutional and legal factors.
- As part of commercial building life-cycle cost analyses in support of the Standards, DOE has begun to evaluate the use of passive solar energy design in commercial office buildings. This passive solar evaluation has focused on the use of natural lighting to reduce the energy required for artificial lighting. Artificial lighting can account for 40% to 60% of the design energy requirements of thermally efficient office buildings. No firm results are available from this study.[42]

DOE's Decisions

In the following ways, DOE took cognizance of its research findings on renewable energy systems and of the Congressional mandate to foster the use of renewable energy resources in the proposed Standards:

[42] AIA Research Corporation, "Life Cycle Cost Study of Commercial Buildings" (draft) (October 1979).

• Energy supplied by solar energy systems is not included in the calculation of the Design Energy Consumption of a building. Effectively, building designs receive a credit for the energy requirements supplied by solar energy systems. That is, a building design may use as little or as much solar energy as the design allows. Thus, this energy is available to reduce the requirements for nonrenewable fuels, making it easier to achieve the Design Energy Budget of the building design with conventional conservation measures.

• In the ANOPR, domestic hot water heating was not included in the design energy requirements for a single-family residence. For the proposed rule, domestic hot water heating is included in the Design Energy Budget of a single-family residence, in part because its inclusion is likely to encourage the use of active solar domestic hot water heating. Under the proposed Standards, the benefit to the home owner or occupant of installing an active solar domestic hot water heater is that it becomes easier to achieve the Design Energy Budget. This is because that part of the domestic hot water heating requirement met by the active solar system is not included in the Design Energy Consumption. In short, the inclusion of domestic hot water in the Design Energy Budget provides a significant incentive for the use of active solar domestic hot water systems over and above already existing incentives.

The issue of encouraging the use of passive solar designs is a more difficult one. The research findings for single-family residents show that such designs are already economically competitive with electric heating in many areas of the Nation, and in some cases with natural gas heating. However, they have not yet achieved widespread acceptance by the design community or the building industry.

DOE believes that the most significant way to encourage building designers to use passive solar design techniques is through an education program informing them of benefits of such techniques and of methods for using them in building designs. The research and publications done in conjunction with the Standards can play a major role in this education process by demonstrating the many opportunities that designers have to use passive solar techniques to meet the Standards.

DOE intends to accomplish this task by widely publicizing its research findings and by assisting the States in implementing the Standards in a manner that effectively informs the building community how passive solar approaches may be used to meet the Standards and, in many cases, reduce costs to the building occupant at the same time. DOE intends to support the development of a Manual of Recommended Practice that will aid building designers and building code officials in understanding a variety of ways in which building designers can comply with the Standards. This Manual of Recommended Practice will include illustrations of passive and active solar designs that can be combined with appropriate conventional conservation measures to produce building designs to meet the Standards.

An additional way in which the Standards may encourage the use of passive solar concepts stems from the selection of the life-cycle cost minimum points as the basis of the Energy Budget Levels for single-family residential buildings. Because these Energy Budget Levels require designers to increase their use of energy conservation beyond common practice, the proposed Standards would encourage the building community to seek new ways of conserving energy that are more cost effective than traditional measures. In this environment in which energy conservation is a requirement, the innovative designer who realizes the potential benefits of passive solar design may have an opportunity to achieve a competitive advantage over designs using traditional techniques only. As noted, the Manual of Recommended Practice will strive to make these opportunities clear to the design community.

Ongoing Research

DOE is continuing its research efforts to gather as much information as possible on ways that solar and other renewable energy systems can meet common economic and energy goals in meeting the Standards. The research effort is also directed at increasing the capability of the Standard Evaluation Technique to analyze renewable energy systems (see Technical Support Document No. 8, Economic Analysis). This research effort is integrated with DOE's ongoing research, development, and commercialization programs for renewable energy systems. This effort includes:

• Development of an element of the Standard Evaluation Technique that treats renewable energy systems not presently included (e.g., wood burning stoves).

• Refinement of the elements of the Standard Evaluation Technique that treat active and passive solar energy systems.

• Continuation of the analysis of passive solar designs for commercial buildings.

• Continued support of analyses for the Manual of Recommended Practice, including evaluation of performance and cost tradeoffs among passive solar designs, active solar systems, and conventional and innovative energy conservation measures in buildings.

• Development of a longer term strategy for updating the Standards in a manner responsive to advances in the state of the art of renewable energy systems.

Request for Public Comment

DOE invites comments on additional ways in which the promulgation of the Standards can serve to encourage the use of renewable sources of energy. In particular, DOE requests public comment on the performance, costs, and availability of innovative methods for reducing the energy consumption of buildings, including innovative ways of using renewable energy resources for this purpose. DOE also requests suggestions on the most effective methods for informing the design and building communities of the opportunities to use passive and active solar and other renewable energy systems to meet the Standards.

2.4.3 Building Design Classifications

Purpose and Scope of the Research

It is necessary to determine clearly and precisely which building designs are subject to which Energy Budget Levels. Some designs present no difficulties (a single-purpose small office building, or a nursing home); others do (a large multifunctional office building containing significant amounts of retail and restaurant space). During Phases 1 and 2, initial building classification systems were developed and surveys were conducted of the energy-related design criteria found in various codes and standards.[43] Also, DOE analyzed the range of functional areas contained in the Phase 2 data base to determine representative distributions for each building classification.[44] The definitions contained in the proposed rule are based on this research.

[43] U.S. Department of Housing and Urban Development and U.S. Department of Energy, "Phase One/Base Data for the Development of Energy Performance Standards for New Buildings, Task Report: Building Classification" (Jan. 1978), and The Ehrenkrantz Group, "Final Report on the Survey of Codes, Regulations and Standards" (Mar. 1978) and "Draft Survey of Codes, Regulations and Standards" (Apr. 1978).

[44] Brookhaven National Laboratories, "The Mix of Functional Areas Within Phase Two Building" (May 1979).

Definition of Issues

The two principal issues involved were:

- Defining building classifications in a manner that would provide clear, unambiguous guidance to users of the Standards.
- Providing a practical mechanism for treating building designs that clearly do not fit within any single classification.

Public Comment on ANOPR

There were two areas of comment to the ANOPR dealing with the issue of building classifications: (1) Comments urging expansion of the number of classifications; and (2) comments encouraging an alternative method of classifying buildings by "functions."

Ten comments concerned the classifications of commercial buildings. The grocery industry objected to inclusion of supermarkets with other mercantile buildings. The industry claimed supermarkets have unique additional energy demands for food preservation. Representatives of retail shopping centers also recommended a separate classification, observing that unique display lighting needs necessitated additional electrical hookups that must be included in the building design to allow for more flexible use of store areas.

Representatives from the industrial sector indicated that the "industrial building" classification encompassed too broad a range of buildings. Hotel and motel industry comments observed that the "hotel and motel" classification contained buildings of vastly different character and purpose. School, college and university groups questioned the wisdom of expecting, say, a chemistry laboratory or swimming pool to have the same Design Energy Budget as a classroom or office building. Finally, two comments suggested that no Design Energy Budgets be set for unusual or infrequently built buildings.

A number of comments criticized the classification scheme for ignoring the fact that many buildings service a variety of functional areas. For example, an office building may contain retail, assembly, restaurant and clinic uses. The comments advocated an application of the building block approach. The representatives of hotels and motels, retail shopping centers and owners of multipurpose buildings were the strongest proponents of this approach.

Work Performed

DOE examined commercial and multifamily residential building designs contained in the Phase 2 research sample and did the following:

1. Identified all functional areas that had been classified in the original Phase 2 research.
2. Assigned areas within each building design in the sample to the approopriate functional classifications.
3. Determined averages and standard deviations for different building functional areas within each building classification.
4. Grouped functions found to have relatively low standard deviations into a single "related purposes" functional classification unique to each building classification, based on consideration of averages and allowances for standard deviations.

DOE also analyzed the results of the single-family residential building sample to establish prototype designs for such buildings. Four prototypes were selected: single-story, two-story and split-level detached, and two-story attached. These four prototypes, described in Technical Support Documents No. 8, Economic Analysis, were analyzed for: (1) Thermal performance, and (2) cost-effectiveness of energy conservation measures.

Alternatives Considered and the Alternative Chosen for the NOPR

Two basic classification alternatives for commercial and multifamily residential buildings were considered: (1) Classifications and definitions based on whole-building functions; or (2) classifications and definitions based on individual functions contained within buildings. The proposed rule in Appendix I provides that, where a building design meets the requirements of a building classification, the Energy Budget Level becomes the Design Energy Budget. For a multiuse commercial building, a functional approach is used. The Design Energy Budget is based upon the relative areas of the functions present in the building design. This approach is used only if Energy Budget Levels can be assigned to at least 50% of the gross area of the building design. If Energy Budget Levels cannot be assigned to 50% of the gross area, the building is not subject to the Standards. DOE seeks comments on whether the Design Energy Budget should instead be applied only to those areas of the building design to which Energy Budget Levels have been assigned.

For single-family residential buildings, the classification procedure is simpler because there is less difficulty differentiating between attached and detached houses. From the research conducted, no significant differences were observed in the design energy requirements for three different prototype designs (one-story, two-story and split-level detached) as reported in Technical Support Document No. 8, Economic Analysis. As a result, DOE has included only two prototypes in the proposed rule: Attached and detached. Research is continuing in order to assess the design energy requirements of additional prototypes: residences with heated basements and residences attached on only one side.

Specific Impact on Proposed Rule

Based on the research, DOE developed the classifications and definitions contained in proposed § 435.04, as well as the exceptions procedure for multifunction buildings, contained in Appendix I.

Ongoing Research

Because the Phases 1 and 2 data were not sufficient to resolve all issues for a building block approach, further research is planned. The analysis will also provide DOE with an improved understanding of the effects of the interaction of building functions on Design Energy Consumption.

Request for Public Comment

DOE is interested in public response to its proposed classification scheme for commercial, multifamily residential and single-family residential buildings. DOE requests comments and data indicating (1) the fraction of building types that fit into different functions, and (2) the degree to which alternative classification schemes can facilitate the implementation of the Standards.

2.4.4 Standard Building Operating Conditions

Definition of the Issues

For each building classification, certain standard building operating conditions are provided to assure that the same conditions of use and occupancy will be used to evaluate the Design Energy Consumption. These standard conditions describe: Hours of operation; indoor temperatures to be maintained; human occupancy densities; and usage profiles for artificial lighting, domestic hot water, elevators, escalators and other energy consuming equipment. These conditions affect Design Energy Consumption to varying degrees, depending on the building type, location, design characteristics, and energy using equipment.

In the development of the proposed Standards, these operating conditions were used in the AXCESS program for commercial and multifamily residential

buildings, and the DOE–2 program for single-family residences. Many of these conditions were assumed or were developed to represent typical values and then used in the research, to introduce consistency in building use for buildings of the same type.[45]

They are also required in the Standard Evaluation Technique used to determine Design Energy Consumption, where they are referred to as Standard Building Operating Conditions.

Public Comments on ANOPR

Many comments concerning operating conditions were received in response to the ANOPR. Several colleges and universities observed that the suggested Standard Building Operating Conditions were not adequate for colleges which have variable occupancy throughout the day, as well as evening programs. They commented that, as a result, college and university energy requirements differ significantly from primary and secondary educational institutions.

In addition, comments relating to the grocery industry proposed that special provisions be made to account for their unique operating conditions. Unlike other retail stores, grocery stores cannot switch off energy consuming equipment (e.g., refrigerators) when the store closes its business day.

The shopping center industry also commented that their operating conditions were distinctive and were not correctly described in the ANOPR. Finally, one isolated comment observed that the "intensity" of use of a building, i.e., the location of people in the building, as well as what those people are doing, is a key consideration. This comment cautioned that too much reliance on a daily occupancy profile, at the expense of the expected intensity of use, could result in a Design Energy Budget having a poor relationship to the actual energy use of the building.

DOE's Proposed Approach

DOE's approach to identifying a method of using Standard Building Operating Conditions with the Standard Evaluation Technique addresses the public comments made in response to the ANOPR and was developed after examining the following three alternatives:

- No standardization, where designers may use any conditions they choose.
- Boundary conditions, which standardize conditions within a fixed range.
- Exact specification, where conditions are set as fixed parameters.

DOE chose to require the exact specification of Standard Building Operating Conditions because the nature and intensity of energy use may vary widely over the useful life of a building.

However, because the Standards are design standards, the Standard Building Operating Conditions are applied to the design. This provides consistency in evaluating building performance, even though two similar buildings in actual operation may be used very differently, with resulting differences in energy use.

To assess a building's Design Energy Consumption fairly, DOE chose to use the operating conditions resulting from the Phases 1 and 2 analyses. The proposed Standard Building Operating Conditions for commerical and multifamily residential buildings (see Technical Support Document No. 5, Standard Building Operating Conditions) thus reflect the averages of designers' estimates of reasonable operating conditions for buildings and for major uses within the buildings. For single-family residential buildings, the conditions reflect the typical conditions indicative of assumed currrent use practices (see Technical Support Document No. 8, Economic Analysis).

The Standard Building Operating Conditions have been developed in sufficient detail to reflect variations in the mix of uses within a given building type. This level of detail permits variations in occupancy density and hours of use in different parts of a building with different functions; for example, a secondary school containing classrooms, offices, a cafeteria and a gymansium. Also, since process energy requirements are not included in the proposed rule, special operating conditions are not necessary for process equipment which must remain on even when a building is unoccupied.

In developing the Standard Building Operating Conditions, DOE determined that they should be based on average current practice, to make the conditions used for design evaluation consistent with anticipated typical building design energy calculations. Further, DOE determined that, insofar as possible, the Standard Building Operating Conditions should not depend on user-oriented devices such as manually operated, movable insulation on windows. The use of such user-operated devices and the energy reductions that are dependent on them cannot be anticipated with sufficient certainty at the building design stage to permit their incorporation into the Standard Building Operating Conditions for the proposed Standards. As empirical data becomes available, DOE may amend the Standards to give credit for the use of such energy conserving design features.

Request for Public Comment

DOE invites public comment on the proposed Standard Building Operating Conditions, especially in regard to their use in conjunction with the Standard Evaluation Technique.

2.4.5 Climate

The Act calls for the Standards to reflect the impact of climate variation (Section 304(b)). Design Energy Budget and Design Energy Consumption will vary from location to location to reflect such climate variations. The purpose of this section of the preamble is to describe the research activities which enabled the climatic variations to be included in the structure of the proposed Standards.

Initial Climate Research, Phases 1 and 2

To determine appropriate relationships between climate variation and building design energy requirements, the relative effects of the elements of climate had to be correlated to design energy requirements data. Such a correlation was not sufficiently developed prior to Phase 1. The initial climate classification system was developed for research purposes only, for regional climate stratification for the selection of building samples, and for data analysis and presentation.

For Phase 1, an initial system of eight regions was developed, based on combinations of heating degree-days (65 °F base) and cooling degree-hours (85 °F base). This system was refined to a seven-region system using heating and cooling degree-days (65 °F base) (see Technical Support Document No. 10, Climate Classification Analysis). This seven-region system was used for analysis purposes throughout Phases 1 and 2.

The initial climate research in Phase 1 examined other existing climate classification systems for their applicability. In Phase 2, an analysis was begun to correlate the impact of climate variables on the design energy requirements results of the Phase 1 base data. However, the results of this analysis were not sufficiently developed by the end of Phase 2 to refine the relationship between climate and building design energy requirements

[45] See Technical Support Document No. 8, Economic Analysis, for their use in single-family residential analysis; Technical Support Document No. 1, The Standard Evaluation Technique, for their use in commercial and multifamily residential buildings; Technical Support Document No. 5, Standard Building Operating Conditions; and footnotes 12 and 14, for a more complete explanation.

beyond the seven-region system used for data analysis.

The ANOPR

The ANOPR suggested the use of the seven climate zones for commercial and multifamily residential buildings. It also suggested three zones for mobile homes because a different methodology was used from that in commercial and multifamily residential buildings. No zones were specified for single-family residences because a procedure using the NAHB Thermal Performance Guidelines was suggested.

Public Response to the ANOPR

Twenty-three comments suggested improvements to the climate analysis and approach presented in the ANOPR.

Eleven comments criticized the use of only seven climatic zones, because the fluctuations in local temperature within each zone create divergent energy requirements. Some comments urged the use of more localized weather zones. Others suggested that degree-days at each specific building site be used in place of climate zones. One comment urged that zones be established for each location for which hourly readings in 5° ranges are available. Seventeen comments indicated a need to adjust climate for factors other than heating and cooling degree-days. These comments advocated consideration of additional climate factors, including relative humidity, wind conditions, and solar radiation. Other comments also urged consideration of specific variables, such as dewpoint, micropressure differences, shade, earth radiation penetration, site orientation, topography, groundwater location, wet bulb temperature, and cloud cover effects.

DOE's Response and Decisions

As explained in Technical Support Document No. 10, Climate Classification Analysis, DOE's approach to climate takes account of these comments. The proposed Energy Budget Levels are displayed for 78 SMSA's and cities. A procedure is outlined whereby any location in the United States can be related, either by proximity or by similarity in weather characteristics, to one or more of these 78 SMSA's and cities. Thus, the proposed approach to climate variations effectively divides the Nation into 78 noncontiguous climate locations and provides Energy Budget Levels for each of these locations. The proposed approach includes a procedure for selecting one of the 78 locations for those cases were a building site is not located within one of the SMSA's or cities listed.

The approach described above resulted from three separate activities commissioned by DOE.

Two independent studies of climate impacts of commercial and multifamily residential buildings were undertaken. Both studies used the Phase 1 descriptions of the commercial and multifamily residential buildings. The studies used statistical techniques, including regression analyses, to develop the relationships between a number of weather variables and the design energy requirements for the sample buildings. The results had been produced in Phase 1, using the short form of the AXCESS computer program and hourly weather data for a representative day for each month of the year.

The first study used classical statistical analyses applied to average energy use figures for each building type by SMSA or city. Atypical or extreme values were deleted from the sample in this analysis because it was felt that such extremes reflected architectural characteristics not germane to the climate analysis. The results of this analysis showed a good correlation, by building type, of energy use as a function of heating and cooling degree-days.

The second study performed a statistical analysis on the entire Phase 1 sample, disaggregated only by SMSA or city, without regard to building type. The results of this study also showed good correlation between energy use of the aggregated Phase 1 building sample and heating and cooling degree-days.

However, both studies were in agreement that there was a need to change the traditional temperature base from which heating and cooling degree-days were calculated.

Also, both analyses examined other weather variables, including solar radiation and humidity. However, these variables did not explain the regional variations in design energy requirements as well as heating and cooling degree-days, nor did they substantially add to the results provided by the heating and cooling degree-day analyses. DOE therefore decided to use degree-day based variables in setting Energy Budget Levels for commercial and multifamily residential buildings.

Both studies further concluded that additional climate analysis using the Phase 1 data would be unproductive due to the city-to-city and building-to-building variability in the data base.

In addition to the proposed climate approach using 78 SMSA's and cities, the first study and additional statistical work in progress have produced results which potentially permit the presentation of climate variation relative to Energy Budget Levels in a more general format. This format is a matrix relating different levels of heating degree-days and cooling degree-days to Energy Budget Levels. Such a format has the potential for: (1) Permitting a Design Energy Budget to be determined directly for any location for which appropriate weather data is available from which to determine heating and cooling degree-days; and (2) applying climate data other than Test Reference Year (TRY) data for determining Design Energy Budgets and Design Energy Consumption.

For single-family residences, a third study was conducted. This study was based on a previous analysis of climate impacts on residential design energy requirements,[46] and on the climate analyses for commercial and multifamily residential buildings. The study examined the impact of climate on the single-family residential prototypes theoretically placed in 10 cities using computer simulation.

This data was used with the residential life-cycle cost analysis to determine the proposed single-family residential Energy Budget Levels for the 78 SMSA's and cities. The results of this study also determined that heating and cooling degree-days, at the same degree-day temperature bases developed from the climate analyses for commercial and multifamily residential buildings, were reasonable for reflecting the location-to-location variation in design energy requirements due to climate.

As part of its ongoing efforts to verify and improve upon the existing research, DOE is considering the development of a representative set of prototypical commercial and multifamily residential building designs to be analyzed for energy and lifecycle costs in differing climates. For single-family residential buildings, DOE is considering further climate research to examine the effects of hour-by-hour climate changes and other climate factors on a set of building prototypes.

Request for Public Comment

Doe is interested in public comment in the following areas:

- The effect of local climatology on building design energy requirements.
- The use of available climate data and its format.

[46] "Geographical Variation in the Heating and Cooling Requirements of a Typical Single-Family House, Using Both Test Reference Year (TRY) and Long-Term Weather Data, and Correlation of These Requirements to Degree Days." U.S. Department of Commerce (June 1977).

• Identrification and quantification of regional building construction and design practices.

• Identification of alternative climate analysis approaches for the evaluations techniques.

2.4.6 Unit of Measure for Design Energy Budgets

An important element of the proposed Standards is the unit of measure for displaying the Design Energy Budgets. The major question is whether MBtu/sq. ft./yr, as proposed in the ANOPR, is the appropriate unit for the Design Energy Budgets.

Public Comment on the ANOPR

The majority of comments received raised no objection to the use of MBtu/sq. ft./yr, but requested further definition and clarification of the reasons for this unit of measure.

Ten comments made suggestions for improving the format of the Design Energy Budgets. Three comments indicated that MBtu/sq. ft./yr required a better definition. Other comments suggested alternative units of measure, such as MBtu/cubic ft./yr (to eliminate the variable of building height) and MBtu/gross conditioned sq. ft./yr. Some thought the unit of measure should be tailored to the building's use; for example, MBtu/bed/yr for hospitals with in-patient care. Still another comment advocated that the unit of measure be tied into an "energy price index."

A second group of comments suggested alternative approaches to the Design Energy Budget. One comment was to use component level budgets. Some comments encouraged the breakdown of the Design Energy Budget into component parts, identifying the precise budgets for HVAC, electricity, domestic hot water, etc. The rationale presented was that a designer needed more specific guidelines.

The last category of comments on the unit of measure indicated that MBtu/sq. ft./yr was impractical or should not be used because there were too many variables which were not adequately considered (i.e., design, tenant mix, function, location, and climate).

DOE's Response and Decisions

DOE is proposing the use of MBtu/sq. ft./yr. This unit of measure and its application are precisely defined in the proposed rule. DOE's analysis subsequent to the ANOPR indicates that, while other parameters may be appropriate for certain building types, the proposed unit of measure provides consistent results for all building types. Possibly, Btu/cubic ft./yr would produce consistent results for certain buildings like warehouses. However, DOE has no evidence that such a change would produce better results. Similarly, the use of units of measure tailored to a specific building type (Btu/bed/yr for hospitals introduces considerable, possibly burdensome, complexity.

The use of MBtu/gross conditioned sq. ft./yr would also introduce additional complexity. For example, this format would make it difficult to account for the lighting energy requirements for nonconditioned spaces.

The specification of separate component Design Energy Budgets may provide more specific guidelines for designers, but may eliminate the use of effective or innovative energy conserving design concepts where tradeoff between components can be used to an advantage. For example, suppose such component Design Energy Budgets existed and a particular building design just met the budgets for both heating, ventilating and air-conditioning (HVAC) and lighting. Suppose also that the designer had a potential design strategy that would save an additional 5 MBtu/sq. ft./yr for lighting but, because of the decreased heat available from the lighting system, would increase the net energy for the HVAC by 1 MBtu/sq. ft./yr. That design strategy would reduce energy for the total building design by 4 MBtu/sq. ft./yr, but the HVAC budget would be exceeded. The increased specificity of the component budget would have restricted the application of an effective overall energy conservation strategy that would trade off increased efficiency in one building system (lighting) for a smaller decreased efficiency in another system (HVAC).

DOE agrees with the comments that the inclusion of energy for domestic hot water in the Design Energy Budget for single-family residences is appropriate because domestic hot water often represents a major energy requirement. Moreover, because of uncertainty in the data on domestic hot water use, DOE will continue its research activities to improve its estimates of domestic hot water contributions to the Design Energy Consumption.

DOE's analysis indicates that domestic hot water use is relatively constant with respect to single-family building size. As such, DOE proposes that the domestic hot water factor of the Design Energy Budget for single-family residences be based on MBtu/yr per single-family unit. This approach encourages the use of solar and other innovative domestic hot water systems as an alternative, with a tradeoff of less stringent thermal integrity in the shell of the building. DOE is particularly interested in comments on this attribute of the proposed rule.

3.0 Selection of the Proposed Energy Budget Levels

3.1 Introduction

DOE considered and evaluated relevant technical and economic information and expert opinion available to it in selecting the proposed Energy Budget Levels (see Technical Support Document No. 3, Energy Budget Levels Selection). DOE determined that the Energy Budget Levels selected should accelerate the use of energy conserving and renewable resource technologies to the maximum extent practicable beyond the level of existing practice and should establish levels of performance achievable by designers through the use of commercially available technology.

DOE analyzed the effects of alternative Energy Budget Levels as a means of focusing its procedure for their selection. These alternative levels were set using the results of the sensitivity analysis of the most critical assumptions, such as fuel prices, stringency of existing energy codes and capital costs (see Technical Support Document No. 8, Economic Analysis). In this manner, the range of possible Energy Budget Levels established a zone of confidence for unanticipated changes in such key assumptions.

DOE's selection of the proposed Energy Budget Levels was not a result of any one analysis, but an informed judgment based on all available information.

An important source of information for the commercial and multifamily residential buildings was the data and information assembled in Phases 1 and 2, including the Phase 2 redesign data (see Section 2.0). This information was supplemented by the analysis of the costs and benefits to the Nation of possible alternative Energy Budget Levels. Added to these considerations were technical, policy, practicability and environmental concerns. DOE also considered the professional judgment of Federal building energy experts who were requested to comment on the alternative design energy requirement levels considered by DOE in selecting the proposed Energy Budget Levels.

For the proposed single-family residential Energy Budget Levels, an important information source was the life-cycle cost analysis conducted for four prototype designs theoretically placed in ten cities representative of varying climate conditions around the country. Additional information was

considered, including the availability of certain conservation technologies, possible detrimental health effects, and a wide range of technical and policy considerations.

The following sections describe the most important information considered in the selection of the proposed Energy Budget Levels for commercial, multifamily residential and single-family residential buildings. Additional information can be found in Technical Support Document No. 3, Energy Budget Levels Selection.

3.2 Commercial and Multifamily Residential Buildings

As noted, DOE considered a number of sources of information in its selection of the proposed Energy Budget Levels for commercial and multifamily residential buildings. A major resource was the analysis of the information assembled in the Phases 1 and 2 research effort. The major factors explicitly considered in DOE's determination of the proposed Energy Budget Levels for commercial and multifamily residential buildings are discussed in sequence in Sections 3.2.1 through 3.2.7 below. These factors are: (1) Expert judgment of Federal officials who administer the design of Federal buildings; (2) economic impacts of alternative possible Energy Budget Levels; (3) practicability of designing buildings to achieve the proposed Energy Budget Levels; (4) level of confidence in the statistical sample of buildings analyzed; (5) technical considerations relating to the accuracy of estimating the energy use of specific building types; (6) health and safety impacts of alternative Energy Budget Levels; and (7) mechanisms available to the Federal Government to encourage strict levels in particular building types.

To provide a framework for evaluating different possible levels of design energy requirements for different types of commercial and multifamily residential buildings, DOE has considered three levels of stringency based on the fraction of redesigns that could achieve a specified level of design energy requirement (see Section 2.0). The three levels of stringency are defined as follows:

- R_{80} means that 30% of all building redesigns for that building type achieved that level of design energy requirement or lower. This level is termed "strict."
- R_{50} means that 50% of the redesigns for that building type achieved that level of design energy requirement or lower. This level is termed "nominal."
- R_{70} means that 70% of the redesigns of that building type achieved that level of design energy requirement or lower. This level is termed "lenient."

For example, the design energy requirement estimates for a large office building in Kansas City, and SMSA selected as representative of a mid-range of climate conditions, were:

R_{80}: 46 MBtu/sq. ft./yr
R_{50}: 49 MBty/sq. ft./yr
R_{70}: 51 MBtu/sq. ft./yr

The proposed Energy Budget Levels were derived by applying weighting factors to these design energy requirements, as discussed in Section 2.4.1. DOE's considerations in the Energy Budget Levels selection process for commercial and multifamily residential buildings are discussed in the following paragraphs.

3.2.1. Expert Judgement

An independent review of R_{80} was conducted by building energy experts from HUD, the Corps of Engineers the National Aeronautics and Space Administration, the National Bureau of Standards, the Department of Defense, the Veterans Administration, and the Department of Health, Education and Welfare. The individuals involved were Federal officials experienced in the administration of the design of energy conserving Federal buildings. They were asked if, based on their experience, they could expect buildings to be designed which could meet the R_{80} level of design energy requirement, or more stringent levels. Their consensus was that the R_{80} levels of design energy requirements could be met, but they felt that these were very strict. Also, there was concern about possible undesirable increases in first cost and design time.

3.2.2 National Economic and Energy Impacts

The net present value to the Nation and the energy savings were estimated for three different levels of design energy requirements: lenient, nominal and strict. An extensive set of analyses was performed to evaluate the degree to which estimated economic impacts depended on the assumptions of energy costs and escalation rates, conservation costs, and other key variables (see Technical Support Document No. 3, Economic Analysis). The results indicated that, for almost all sensitivity cases considered, the net present value to the Nation of the proposed Energy Budget Levels was greatest for the strict case and lowest for the lenient case. Thus, national economic benefits are greatest for the more strict levels.

3.2.3. Practicability

This consideration included qualitative assessments by DOE of the practicability of designers being able to achieve energy conservation levels significantly more stringent than current practice. DOE has identified many instances where it appeared that designers would experience difficulty in reaching the strict range of design energy requirements, in spite of the apparent national cost-effectiveness of such levels. DOE believes that a major constraint in the designs of more energy-efficient commercial and multifamily residential buildings is not technology or costs but the unfamiliarity of design professionals with energy-efficient design strategies and available technology. DOE believes that this aspect of practicability is a strong deterrent against very strict Energy Budget Levels, at this time.

DOE has carefully evaluated the preliminary results of a life-cycle cost study of large office buildings.[47] This study suggests that there are designs that are economically beneficial at design energy requirement levels more stringent than those achieved by most of the redesigns in Phase 2. Again, however, the unfamiliarity of the design community with energy-efficient design strategies that would produce designs that would meet these stringent levels is an important consideration against setting levels that are too strict.

3.2.4 Confidence in the Samples Selected

Confidence in the sample was evaluated qualitatively in terms of three factors for each building type: Sample size, variability, and regionality problems. For example, for two building types, hospitals and multifamily low-rise residences, there was less confidence in the represenativeness of the sample than for other building types.

3.2.5 Technical Considerations

These included qualitative assessments of: (1) Process loads (the difficulty of separating process energy from other energy uses in calculating design energy requirement), and (2) evaluation technique capabilities for calculating design energy requirements for each building type. For example, the amount of process energy used for restaurant kitchens is generally much greater than the energy used for space conditioning in those buildings. DOE is considering research to develop an approach for studing the interactions

[47] AIA Research Corporation, "Life Cycle Cost Study of Commercial Buildings" (draft) (October 1979).

between process energy requirements and design energy requirements for space heating and cooling, lighting, ventilation, domestic hot water and elevators and escalators, all of which support human occupancy.

The proposed rule also contains no proposed Energy Budget Levels for two building classifications, restaurants and industrial buildings, because of the difficulties of separating process energy from other energy uses. DOE is considering further research to identify the non-process energy related design energy requirements of different types of restaurants and industrial buildings.

3.2.6 Health and Safety Considerations

The major health and safety issue of the proposed Standards identified in the Draft Environmental Impact Statement (Technical Support Document No. 7), is the potential impact of reduced rates of ventilation or air infiltration on indoor air quality. As discussed in Section 2.3.1, all of the proposed Energy Budget Levels can be achieved without any change in ventilation or air infiltration of commercial or multifamily residential buildings. Furthermore, the Standard Evaluation Technique (Section 4.0) is formulated so that it gives no credit for ventilation or air infiltration levels below current practice and the local requirements that are meant to protect the public health and safety.

Thus, under the proposed rule, the indoor air quality is not expected to change, regardless of whether the Energy Budget Levels are set at lenient, nominal, or strict rates.

3.2.7 Influence of Federal Government on Building Design

This included the potential of the Federal Government to influence construction practice for projects that receive substantial Federal funding, such as schools and hospitals. This potential could be developed by providing technical assistance to the designers of such buildings or by requiring energy efficient designs as a condition of Federal funding. This factor did not have a major role at this time because the mechanisms for exerting this influence have not yet been established and because of the particular concern about interior air quality in the two building types that would be affected, schools and hospitals.

3.2.8 Overall Assessment

Based upon the combined qualitative assessment of all of the above considerations for each building type, the following proposed Energy Budget Levels were selected.

- Large and small office buildings: R_{30}.
- Hospitals and multifamily low-rise residential buildings: R_{70}.
- All other commercial and multifamily residential buildings: R_{50}.

3.2.9 Component Performance Standards: Comparisons and Potential Equivalency

As noted in Section 2.2, impacts on design energy requirements of the proposed component performance standard ASHRAE 90–75R (November 1977) and the draft version (April 1978) of the HUD Minimum Property Standards were analyzed using the Phase 2 commercial and multifamily residential sample buildings. Applying the minimum requirements of the HUD standards to the multifamily residential buildings resulted in average design energy reductions in the range of 7% to 11% from 1975–1976 practice. The design energy reductions produced by the proposed Energy Budget Levels from 1975–1976 for these buildings types in more than two times as much as the reduction projected from the HUD standards.

The preliminary results of the analysis of the ASHRAE 90–75R component performance standard are available at this time for the Phase 2 small office building sample only. These results indicate that the minimum requirements of ASHRAE 90–75R, for those small office buildings, produce a design energy reduction from 1975–1976 practice of about one-half of the design energy reduction level of the small office building redesigns.

In addition, DOE has initiated preliminary analyses toward determining potential "equivalency" between a standard based on ASHRAE 90–75R and the proposed Energy Budget Levels. Changes were made to each relevant section of the ASHRAE standard to increase its stringency. Then, energy calculations were made which reflected the impacts of the more stringent measures. Those energy calculations were made for the Phase 2 sample of small office buildings and warehouses. The preliminary results of the more stringent component requirements based on ASHARE 90–75R produced average design energy requirement levels within 2 percent of the redesign levels for each of the two building types.[48] The changes made to increase stringency are currently being evaluated by DOE for technical feasiability and practicability.

[48] AIA Research Corporation Memorandum, "Preliminary Results of Potential Improvements to ASHRAE 90–75R to Determine Possible Equivalence to the Mean of the Phase 2 Redesign Buildings" (August 1979).

Also, DOE is initiating a more extensive program to develop measures of equivalency based on prototypical building designs.

3.3 Single-Family Residences

For single-family residences, DOE sought to select Energy Budget Levels that could be achieved using available conservation measures, would result in housing design changes that would be financially beneficial to the owner, would produce significant aggregate energy savings to the Nation, and would result in greater conservation than present energy standards or current practice.

The analysis conducted in support of DOE's selection of the proposed Energy Budget Levels first involved identifying currently used energy conservation measures and evaluating the cost and design energy requirements of using different combinations of these measures at different locations in the country. Ten cities were selected to represent a broad range of climates. For each city, four single-family residential prototypes were evaluated using different combinations of conservation measures and different fuel sources (gas, oil, and electricity). For each combination of conservation measures and fuel type, the analysis determined: (a) The life-cycle cost (i.e., the sum of (1) the future fuel costs discounted to the present, and (2) the investment in energy conservation measures above current practice), and (b) the design energy requirement for each prototype house.[49] This procedure made it possible to identify the combination of energy conservation measures that produced a minimum in the life-cycle cost. The procedure made it possible to identify the combination of energy conservation measures that produced a minimum in the life-cycle cost. The procedure also made possible the evaluation of the increase in life-cycle cost due to all other combinations of conservation measures for each of the fuel types.

DOE has decided to set the proposed single-family residential Energy Budget Levels at the minimum in life-cycle costs, as determined by the procedure outlined above. The basis and reasoning for this decision are discussed below.

[49] Life-cycle cost curves were generated by simulating the change in design energy requirements resulting from the addition of a series of energy conservation measures. The conservation measures were added in order of declining cost-effectiveness. Conservation measures included wall insulation (up to R–25), ceiling insulation (up to R–38), increased number of glazings on windows (up to three), and floor insulation (if a house had a crawl space.) Details are contained in Chapter 4 and Appendix A of Technical Support Document No. 8, Economic Analysis.

First, it is useful to recognize that there is considerable uncertainty regarding the precise identification of the life-cycle cost minimum. This uncertainty derives from a lack of complete information about local and regional variations in such factors as climate, energy prices, energy conservation costs, and "performance" of different energy conservation measures under a range of conditions and in houses that differ from the prototype designs used in the analysis. Therefore, the minimum life-cycle cost is more a range than a single point on the life-cycle cost curve.

The range is further broadened in some climates because several conservation measures near the minimum have approximately equal life-cycle costs. There is a regional pattern to the breadth of the minimum range on the life-cycle cost curve. In the colder climates, the life-cycle cost curve ends before a true minimum is reached and only unconventional conservation measures can further reduce energy use. In the warmest regions, for natural gas heated homes, additional conservation measures can be achieved at little additional cost. However, DOE is concerned that setting more stringent Energy Budget Levels than those at the life-cycle cost minima might have adverse impacts on the building industry, particularly in cold and moderate climate areas, during a transition period while the industry is adapting to the new Standards.

A number of analyses were undertaken to determine the effects upon life-cycle costs and energy requirements due to changes in the assumptions characterizing the prototype designs, conversation costs, energy prices and price escalation factors, and other variables of the analysis. Reports of these analyses are contained in Technical Support Document No. 8, Economic Analysis.

As a further step in establishing the practicability of the minimum life-cycle cost level, DOE conducted specific analyses to determine whether alternative conservation measures, not used to establish the life-cycle cost levels, could be used to meet the minimum level. In addition, DOE identified specific localities where there was some question as to whether the conservation measure used to establish the minimum point could be utilized. In these cases, DOE conducted analyses that indicated that alternative conservation measures could be utilized, in lieu of the questionable measure, to meet the minimum levels.[50]

Once DOE was satisfied that the minimum life-cycle cost level was reasonable and achievable, DOE then analyzed a number of important issues to determine whether alternative design energy requirement levels, more or less restrictive than those based on the life-cycle cost minima, would be preferable for the proposed rule.

DOE evaluated four alternative levels in reaching its decision:

1. The minimum point on the life-cycle cost (LCC) curve (called the LCC minimum).
2. 10 percent tighter than the LCC minimum.
3. 20 percent tighter than the LCC minimum.
4. 25 percent to 30 percent looser than the LCC minimum (equivalent to the HUD Minimum Property Standards).

Each of these four alternatives was evaluated with respect to: (1) Energy savings to the Nation, (2) economic impacts on individuals and the Nation, (3) practicability of designing buildings to meet the levels indicated, (4) first-cost (i.e., increased initial investment) impacts, (5) environmental impacts, and (6) degree to which the levels would be likely to encourage the use of renewable energy systems. The results of the investigation of these factors are summarized below and are discussed in greater detail in Technical Support Document No. 3, Energy Budget Levels Selection.

3.3.1 Energy Savings

The cumulative energy savings during the time period 1980 to 2020 resulting from the four alternative levels have been estimated using the Oak Ridge National Laboratory Residential Energy Demand Model (see Technical Support Document No. 8, Economic Analysis). The estimated savings were:

- More than 11 quadrillion Btu's (quads) for alternative 1, the LCC minimum.
- About 14 quads for alternative 2.
- About 16.5 quads for alternative 3.
- About 4.5 quads for alternative 4.

DOE also investigated the energy savings associated with the first alternative under the assumption that the Energy Budget Levels were made stricter by future updating, justified by higher energy prices (in accord with DOE's estimates of increasing real prices of energy). The cumulative energy savings associated with the minimum LCC level was about 15 quads, 4 quads greater than that without updating. Thus, the energy savings for all of the alternatives are underestimated if the Energy Budget Levels are made more strict through periodic updating.

3.3.2 Economic Impacts

The first three alternatives (minimum LCC, minimum LCC minus 10%, and minimum LCC minus 20%) were shown to have approximately equal and favorable economic impacts. Alternative 4 had considerably reduced economic benefits to the homeowner/occupant and to the Nation. (The estimated net benefit of alternative 4 was less than one-third that of the other alternatives, as shown in Technical Support Document No. 3, Energy Budget Levels Selection.)

3.3.3 Practicability of Proposed Energy Budget Levels

DOE's analysis raises concern that the two alternatives that are stricter than the minimum life-cycle cost are:

1. Not easily achievable in some cases because of the lack of information available to house designers, or the inadequate commercial availability of materials or components needed to meet the more stringent levels (e.g., lack of information about passive design options; difficulty in obtaining windows with triple glazing).
2. May be achievable for some, but not all, sites in many areas, because of limitations in the way that a building can be oriented, or due to unavailability of unobstructed access to sunlight.

DOE believes that the minimum in life-cycle cost levels (alternative 1) or more lenient levels (alternative 4) can be achieved using available technology.

3.3.4 First Costs

The increase in the first cost of alternative 1 (the minimum LCC) is estimated to be between $750 and $1500 in moderate and colder climates for an average new house of 1500 square feet (Technical Support Documents No. 8 and No. 3). Alternative 2 is estimated to require an increase of about 30% in first costs over that of alternative 1 if the designer is familiar with cost-effective ways of achieving a lower Design Energy Consumption. However, because of uncertainty in the availability of information and components, this increase in first cost could be considerably more, or somewhat less, than the estimated amount. Alternative 3 is estimated to have an initial investment approximately twice that of alternative 1.[51] Alternative 4 is

[50] See Technical Support Document No. 8, Economic Analysis, Appendices A and I, for details.

[51] As noted in Technical Support Documents No. 3 and No. 8, the initial investment required to achieve budget levels tighter than the LCC minimum is expected to decline over time as new energy conservation technology for residential buildings achieves commercial acceptance.

estimated to have 30% lower first costs than alternative 1.

As a result of the above analysis, DOE is concerned that Energy Budget Levels tighter than the minimum LCC levels could create an increase in building first costs that might intensify the present slowdown in the residential construction market.

3.3.5 Environmental Impacts

As noted in Section 2.3.1, the major area of potential environmental impact associated with the Energy Budget Levels is indoor air quality. The proposed Standards are designed so that no credit is given at this time for reducing air infiltration rates. As a result, all four alternatives are expected to have the same (i.e., negligible) impacts on indoor air quality.[52]

Because the more stringent alternatives result in greater reductions in the net air pollution caused by energy production, transmission, and use,[53] the strictest alternative (3) is expected to have the most favorable total impact on the physical environment. The most lenient alternative (4) has the least favorable impact on the physical environment, because it results in significantly smaller energy savings than the other three alternatives.

3.3.6 Renewable Energy Systems

DOE wishes to encourage innovative building designs which make use of solar and other renewable energy sources, as well as new methods of energy conservation. Setting the Energy Budget Levels at the LCC minimum (alternative 1) encourages the development and implementation of new design approaches. It requires the use of energy conservation measures that are more stringent than those used by most builders today. Alternatives 2 and 3, because they require even greater use of innovative measures to reduce energy use, could serve to further encourage the use of renewable energy systems in building designs. Alternative 4, the most lenient level, is anticipated to have little effect on encouraging the use of renewable energy systems in buildings.

Other aspects of the proposed Standards may be as important as the levels of the Energy Budget Levels in encouraging the use of renewable energy systems. One example is the effort to disseminate information that illustrates how systems, such as active and passive solar energy systems, can be used in designs to facilitate achieving compliance with the proposed Standards in different regions of the country. This and related issues are discussed in Section 2.4.2.

3.3.7 DOE's Decision on Energy Budget Levels

DOE considered the results of the analyses, as reflected in the summary discussion above, and decided to set the Energy Budget Levels for single-family residences at the minimum life-cycle cost levels. The reasons against selecting the stricter levels of alternatives 2 and 3 were (1) DOE's assessment of the difficulty of achieving those levels at the present time, and (2) the higher first costs associated with those stricter levels. The reasons against the more lenient level of alternative 4 were that it would result in (1) considerably lower energy conservation than the other alternatives, (2) less favorable economic and environmental impacts, and (3) virtually no encouragement of the use of renewable energy systems.

As noted previously, the LCC minimum points are generally reflective of the levels of an average residential building designed to maximize the economic benefits to the building owner/occupant. Because of uncertainty and variations in energy prices, conservation costs, building designs and climates, individual buildings will exhibit a range of minimum life-cycle cost points that are expected to center about the point chosen by DOE. Furthermore, as energy prices rise and as the costs of new energy conservation measures fall, more stringent Energy Budget Levels may be appropriate. For these reasons, DOE anticipates updating the Standards.

To assess the nature of the proposed single-family residential Energy Budget Levels, DOE compared them with already existing standards, i.e., the HUD Minimum Property Standards (MPS).[54] The Economic Analysis (Technical Support Document No. 8) also compares the two standards and shows that the proposed single-family residential Energy Budget Levels are more stringent than the HUD Minimum Property Standards, are more desirable economically than the HUD Minimum Property Standards and can be achieved using current building practices.

Table 3-1 illustrates several sets of options for meeting the proposed single-family residential Energy Budget Levels for three locations. These are some of the ways the Energy Budget Levels reported in Appendix I to the proposed rule can be achieved.

Table 3-1.—*Illustrative Ways of Meeting the Proposed Energy Budget Levels for Single-Family Residences In Three Locations*

Gas heated homes	
Location	Sets of options
Chicago, IL	1. Average window area and distribution [a]; triple glazing [b]; R-38 ceiling and R-19 wall insulation
	2. Windows redistributed so that south facing window area increased by 75%, and east, west, and north facing window area decreased by 25%; double glazing; R-38 ceiling and R-19 wall insulation
	3. Active solar domestic water heating system [d]; double glazing, R-38 ceiling and R-11 wall insulation
Atlanta, GA	1. Average window area and distribution [a]; double glazing; R-38 ceiling, R-19 wall, and R-11 floor [c] insulation
	2. Windows redistributed so that south facing window are increased by 75%, and east, west, and north facing window area decreased by 25%; double glazing, R-30 ceiling and R-11 wall and R-11 floor insulation
	3. Active solar domestic water heating system [d]; double glazing; R-19 ceiling, R-11 wall and R-7 floor insulation
Houston, TX	1. Average window area and distribution [a]; double glazing; R-30 ceiling and R-11 wall insulation
	2. Active solar domestic water heating [d]; R-19 ceiling and R-11 wall insulation
	3. Other alternatives, such as passive solar design and redistribution of windows, not evaluated for Houston
Chicago, IL	1. Average window area and distribution [a]; triple glazing [b]; R-38 ceiling and R-25 wall insulation; heating supplied by a heat pump
	2. Windows redistributed so that south facing window area increased by 36%, and east, west, and north facing window area decreased by 12%, triple glazing; R-38 ceiling and R-19 wall insulation; heating supplied by heat pump
	3. Active solar domestic water heating system [d]; double glazing; R-38 ceiling and R-25 wall insulation; heating supplied by electric resistance
Atlanta, GA	1. Average window area and distribution [a]; triple glazing [b]; R-38 ceiling, R-19 wall, and R-11 floor [c] insulation; heating supplied by heat pump
	2. Windows redistributed so that south facing window area increased by 80%, and east, west, and north facing window area decreased by 27%; double glazing; R-38 ceiling, R-19 wall and R-11 floor [c]; insulation; heating supplied by heat pump
	3. Active solar domestic water heating system [d]; double glazing; R-30 ceiling, R-19 wall, and R-11 floor [c]; insulation; heating supplied by electric resistance
Houston, TX	1. Average window area and distribution [a]; triple glazing [b]; R-38 ceiling and R-19 wall insulation; heating supplied by heat pump
	2. Active solar domestic water heating [d]; R-19 ceiling and R-11 wall insulation

[52] DOE anticipates that improvements in (1) the measurement of air infiltration rates, (2) the knowledge of relationships between building design, construction, and air infiltration rates, and (3) technologies (such as heat recuperators) that may permit low levels of infiltration without adverse impacts on air quality, may in the future make it possible for DOE to give credit for reductions in air infiltration rates.

[53] Technical Support Document No. 7, Draft Environmental Impact Statement.

[54] Lawrence Berkeley Laboratory, "Residential Energy Performance Standards: Comparison of HUD's Minimum Property Standards and DOE's Proposed Standards," LBL-9817 (October, 1979) This report compares key features of the two standards, summarizes the assumptions used in developing them, and shows how the HUD/MPS could be modified to be consistent with DOE's proposed Standards.

Table 3-1.—*Illustrative Ways of Meeting the Proposed Energy Budget Levels for Single-Family Residences In Three Locations*—Continued

Gas heated homes	
Location	Sets of options
Houston, TX	3. Other alternatives, such as passive solar design and redistribution of windows, not evaluated for Houston

[a] The average window area is 15% of total floor area. The windows are distributed equally among the exterior walls.

[b] Double glazing plus storm windows can substitute for triple glazing with little change in the Design Energy Consumption of the house.

[c] Floor insulation is noted in Atlanta, Georgia and all other areas where crawl space basements are used.

[d] The active solar domestic water system is assumed to supply 60% of the domestic hot water in a 1500 square foot house for the purpose of this illustration.

4.0 Building Design Evaluation Techniques

4.1 Introduction

The proposed rule provides two approaches for determining compliance with the Standards:

(1) A performance approach: Calculating the Design Energy Consumption of a building design for comparison with the Design Energy Budget applicable to that building design. For this approach, proposed § 435.03 requires the use of an evaluation technique to calculate the Design Energy Consumption. The evaluation technique may be either the Standard Evaluation Technique, which is included specifically in the proposed Standards and is described below, or an alternate evaluation technique, approved in accordance with proposed § 435.06.

(2) An equivalent approach: Complying with the requirements of a model code or Manual of Recommended Practice which has been determined to be "equivalent" to the Standards. The evaluation technique discussed here applies to the performance approach.

DOE has examined the issues surrounding the process by which the Design Energy Consumption of a building design may be determined. The process combines a number of diverse specializations, including computer science, climatology, engineering and architecture. It is also a process about which there is considerable diversity of professional opinion regarding which approach is best suited for use as part of these Standards.

DOE is proposing to establish the Standard Evaluation Technique to provide a method for calculating the Design Energy Consumption of a building design. The calculation method in the Standard Evaluation Technique was chosen from among many energy calculation methods currently in use.

The selection process is explained in Technical Support Document No. 1, The Standard Evaluation Technique. That document describes in detail the criteria and selection process used in establishing the Standard Evaluation Technique, as well as related technical and economic issues.

In addition, the document provides considerable detail regarding the Standard Evaluation Technique calculation methods and their capabilities, limitations, accuracy, ease and cost of use, and future development.

The discussion in this section of the preamble describes how the Standard Evaluation Technique relates to the proposed Standards and also outlines the procedure for developing alternate evaluation techniques.

4.2 Elements of Building Design Evaluation Techniques

Energy calculation methods are used for a variety of tasks in the building design process and in the examination of the energy consumption of existing buildings. Although energy calculation methods have been available for a number of years, there has been a notable proliferation in both the number of available methods and their use since the oil embargo of 1973–1974.

The traditionsl use for energy calculation methods is as a design tool to evaluate the energy efficiency of building design alternatives. This includes such analyses as:

- Comparing alternative HVAC systems to select the one best suited for the building.
- Comparing various wall compositions to assess energy savings at different constuction costs.
- Determining the energy savings due to "retrofit" energy conservation methods.
- Sizing solar energy collection systems.

Because of the role of evaluation techniques in these Standards, DOE believes it is important to distinguish between energy calculation methods, which are widely used in the building design process, and the Standard Evaluation Technique in this proposed rule. The Standard Evaluation Technique may be viewed as an energy calculation method to which certain fixed parameters and instructions have been added. Further, the application of the proposed Standard Evaluation Technique is more limited in scope, as it is used to determine, in a controlled manner, a building's Design Energy Consumption.

Designing buildings under a performance approach will mean choosing among various tradeoffs available to the designer, a task well suited for easy-to-use and cost-effective energy calculation methods. DOE feels strongly that the evaluation techniques can play an important part in the building design process and wishes to encourage their use in that process.

The Standard Evaluation Technique for the proposed Standards is composed of three major elements:

- An energy calculation method consisting of a set of mathematical equations which approximate the actual operation of a building based on its design.[55]
- Fixed parameters, used as data for the calculation method, which establish a consistent basis for comparing the Design Energy Consumption of a building design to its Design Energy Budget. This set of fixed parameters includes:

—Weather data.

—Standard Building Operating Conditions.

—Certain fixed data as specified by DOE.

- Procedures (i.e., instructions) for the combined use of both the calculation method and the fixed parameters, which result in the calculation of Design Energy Consumption for a building design.

These same three basic elements will also be present in any approved alternate evaluation technique.

An evaluation technique must provide a consistent framework in which building designs can be evaluated. There are certain factors, such as building operating conditions which, if varied by the designer, could significantly affect the Design Energy Consumption of a building design. If such factors are held constant from one

[55] Tables 1, 2 and 3 in Appendix IV of Technical Support Document No. 1, The Standard Evaluation Technique, identify all subroutines of the Standard Evaluation Technique programs that utilize algorithm or calculation values that were developed by private individuals or organizations with recognized expertise in the particular area. Since these algorithms and calculation values are not commercial standards as contemplated by Section 32 of the Federal Energy Administration Act of 1974 (15 U.S.C. 761 *et seq.*), determinations pursuant to Section 32(a) are not deemed necessary. Nevertheless, DOE considers it important that the public be provided with information concerning the source of algorithms and calculation values used in the Standard Evaluation Technique. Furthermore, as would be provided to the public were Section 32 applicable, DOE has determined that none of the algorithms or calculation values listed in Tables 1, 2 and 3 of Appendix IV was developed in accordance with the criteria set forth in Section 32(b) concerning public participation in the development process. It should be noted, though, that DOE experts have independently evaluated each subroutine item listed in the referenced tables, without regard to source, and determined that each represents the best available algorithms or calculation values.

building design to another, the calculation of Design Energy Consumption can be done on a fair and equitable basis.

When energy calculation methods are used in their traditional roles, as previously discussed, a consistent framework for comparison purposes is often used. It is common practice, for example, when comparing the energy requirements of alternative HVAC systems, to hold all other building data constant from one comparison to another. This is done so that the energy related aspects of the HVAC system under study can be evaluated. Energy calculations of this type would be of little value if the weather data or building occupancy patterns were allowed to vary from one comparison to another.

This same approach has been adopted by DOE in the Standard Evaluation Technique, which is structured to provide a consistent framework in which the energy related aspects of a building design can be isolated and evaluated.

4.3 Definition of the Standard Evaluation Technique for the Proposed Rule

DOE considers it essential that the Standard Evaluation Technique be readily available, precisely defined and in the public domain. The proposed Standard Evaluation Technique meets these requirements and consists of the following:

- The Standard Evaluation Technique calculation methods: three public domain computer programs, DOE–2, TRNSYS and DEROB, and their supporting documentation and user's manuals.
- The Standard Evaluation Technique fixed parameters: weather data, Standard Building Operating Conditions, and certain fixed data as specified by DOE.
- The Standard Evaluation Technique procedures (instructions): A detailed set of instructions for using the Standard Evaluation Technique calculation methods and fixed parameters. The instructions include:

—Selection of the appropriate public domain computer program to use with a specific building design.

—Selection of the appropriate weather data and Standard Building Operating Conditions.

—Use of the public domain calculation methods selected, including the requirements for data associated with the building design.

—Application of weighting factors to the building design energy requirements by fuel type (gas, oil and electricity) to determine the Design Energy Consumption of the design.

4.3.1 The Standard Evaluation Technique Calculation Methods

The current state of the art in building energy calculation methods is not sufficiently developed to support a single computer program for the energy analysis of all building classifications; heating, ventilation and air-conditioning systems; lighting; domestic hot water heating systems; and nonrenewable energy sources. The reasons for this are discussed in detail in Technical Support Document No. 1, The Standard Evaluation Technique, and briefly in Section 4.5 of the preamble. Therefore, DOE is providing the three computer programs indicated as the calculation methods for the Standard Evaluation Technique.

Their applications for this proposed rule are indicated in the matrix which follows. This matrix indicates that, for purposes of evaluating Design Energy Consumption, DOE is proposing three categories of building types and generic HVAC system configurations:

- Single-family residential.
- Commercial, with unitary HVAC systems.
- Commercial, with central HVAC systems.

Building category	Conventional systems	Passive solar	Hybrid solar	Active solar
Single-family residential	DOE–2	[redacted]	(1)	DOE–2/TRNSYS
Commercial unitary	(1)	(1)	(1)	(1)
Commercial Central	DOE–2	(1)	(1)	DOE–2/TRNSYS

[1] Not presently available. Planned for the final rule. (Section 4.5.2)

Within the single-family residential category are included both attached and detached residences, as defined in proposed § 435.04. All other building classifications defined in the proposed rule are considered "commercial" for purposes of using the Standard Evaluation Technique. Unitary systems are defined as packaged HVAC equipment such as window air-conditioners, through-the-wall conditioners, and rooftop units. The equipment is distinguished from central plant components in that multifunctional components have been prepackaged on an assembly line. Central systems are defined as systems characterized by a central plant (chillers, boilers, furnaces, etc.) servicing several conditioned areas via a distribution system. The distribution system can be all air (variable volume, dual-duct, etc.), air-water (two-pipe, induction, dual-duct, etc.), or all water (fan-coil units with wall apertures, etc.).

Also, the matrix divides building energy systems into two categories:

- Designs which are considered conventional and use nonrenewable energy.
- Designs which include energy systems that utilize solar energy.

At the present time, the Standard Evaluation Technique does not treat any other renewable energy resource. Definitions of active, passive and hybrid solar energy systems are found in Technical Support Document No. 1, The Standard Evaluation Technique.

The following paragraphs briefly describe each of the Standard Evaluation Technique computer programs and their capabilities. A more extensive description is found in Technical Support Document No. 1.

DOE–2

This computer program is used to calculate the design energy requirements of non-solar single-family residential buildings and commercial buildings with central HVAC systems. It is also used to calculate building loads for processing by the TRNSYS program in calculating the design energy requirements in single-family residential buildings and central HVAC system commercial buildings which utilize active solar energy systems.

Given information on the building's intended location, construction, operation, ventilating and air-conditioning equipment, DOE–2 calculates the estimated hour-by-hour energy requirements of a building. It has three main calculation sections, as used in this proposed rule: LOADS, SYSTEMS, PLANT. The LOADS section calculates the hourly heating and cooling load for each thermal zone within the building. SYSTEMS simulates the operation of the HVAC distribution system. PLANT simulates the operation of primary energy conversion equipment, such as boilers and chillers.

TRNSYS

This computer program is used to calculate the contribution of an active solar energy system toward a building's heating, cooling and domestic hot water heating fuel requirements. It is used in conjunction with the DOE–2 program and is applicable to single-family residential and commercial buildings. TRNSYS was developed primarily to analyze the behavior of active solar heating and cooling systems. TRNSYS has the ability to simulate the interconnection of a wide range of possible component designs, controls, and system configurations for active solar energy systems.

DEROB

This computer program is used to calculate the design energy requirements of single-family residential building designs which incorporate passive solar energy systems.

DEROB is structured to allow a sophisticated analysis of most of the currently recognized passive solar design features. DEROB is the only public domain energy analysis program available which has the capability to adequately analyze complicated building geometries which incorporate passive solar energy design features such as direct gain or Trombe walls.

The three computer programs, their supporting documentation and user's manuals describe the Standard Evaluation Technique calculation method. The sources of these computer programs and their documentation are given in Table 1 in the proposed rule. DOE anticipates that the private sector will respond to the need for ready access to the Standard Evaluation Technique by making available the Standard Evaluation Technique calculation method, criteria and procedures on a time sharing basis through a number of computer service bureaus.

4.3.2 The Standard Evaluation Technique Fixed Parameters

In developing the fixed parameters, DOE had three objectives:

(1) Minimize the impact of the fixed parameters on building design flexibility.

(2) Achieve an acceptable degree of replicability among users of the Standard Evaluation Technique.

(3) Adhere, to the extent possible, to (a) the methodology used in the process by which Energy Budget Levels were developed for this proposed rule, and (b) the values typical of actual building operating conditions.

Climate Data

The climate data for the proposed rule is the National Oceanic and Atmospheric Administration (NOAA) Test Reference Year (TRY) data for 78 SMSA's and cities. The TRY data provide information on weather conditions, including temperature, humidity, cloud cover as an index of solar radiation, and wind on an hourly basis for the 8,760 hours of a year. The TRY data are recorded climate data for a year, selected to represent the climate for a location.

The Standard Building Operating Conditions

The length of time of use and the intensity of use of a building during the course of a year will affect its annual energy use. During the design of a building, the future use of a building cannot be precisely predicted. However, reasonable estimates of typical use can be made. As part of the Standard Evaluation Technique, these estimates of typical use have been made standard for each building design classification and, where appropriate, for each major function within a building design classification. They have been designated Standard Building Operating Conditions, and provide a consistent basis for calculating Design Energy Consumption for building designs reflecting similar uses.

Standard Building Operating Conditions are to be used with the Standard Evaluation Technique for the following:

(1) Occupancy
(2) Artificial lighting
(3) Domestic hot water
(4) Elevators and escalators (vertical transportation)
(5) Toilet exhaust
(6) General exhaust
(7) Indoor temperature conditions

Certain Fixed Data Values

Because the results of energy calculation methods can be greatly affected by certain values involving assumptions and approximations by the user, DOE has elected to fix certain data values to provide greater consistency in the calculations. For example, national holidays, daylight savings time and a January 1 to December 31 calculation period have been specified as part of these fixed data input variables. For additional details, see Technical Support Document No. 1, The Standard Evaluation Technique.

4.3.3 The Standard Evaluation Technique Procedures

The procedures in the Standard Evaluation Technique for calculating the Design Energy Consumption of a building are outlined below. Complete details are provided in Technical Support Document No. 1, The Standard Evaluation Technique.

Step 1: Select the Appropriate Standard Evaluation Technique Computer Program for a Particular Building

The Standard Evaluation Technique provides a procedure so a user can determine which computer program is appropriate to use for an HVAC system and building type combination as shown in the matrix in Section 4.3.1.

Step 2: Select the Appropriate Weather Data

Proposed Appendix II sets out the procedure for choosing appropriate weather data which includes the following basic steps:

(1) If the site of the building design is within the boundaries of one of the 78 SMSA's or cities listed in Appendix II of the proposed rule, use the TRY weather data for that SMSA or city.

(2) If not, then: (a) Select the SMSA or city with weather data most closely approximating the weather local to the site, based on criteria given in Appendix II of the proposed rule. If this selection criteria cannot be met, then

(b) Select the closest SMSA or city within 5 degrees latitude of the site.

(3) If the building design requires local weather data to develop the energy conservation strategies of the design and no TRY weather data is available to approximate local conditions, an exceptions procedure will be provided.

Step 3: Identify the Applicable Standard Building Operating Conditions

Once the building design classification has been determined from the definitions in § 435.04 of the proposed rule, refer to Technical Support Document No. 1, The Standard Evaluation Technique, to select the applicable Standard Building Operating Conditions.

Step 4: Use the Calculation Method

Select the appropriate computer program from instructions in Technical Support Document No. 1, The Standard Evaluation Technique. Develop data from the building design, use the Standard data and calculate the building's design energy requirements.

Step 5: Apply the Weighting Factors to Derive Design Energy Consumption

This last step is applied to the building's design energy requirements as calculated, to take into account the weighting factors discussed in Section 2.4.1 of the preamble to this proposed

rule (see instructions in Technique Support Document No. 1, The Standard Evaluation Technique, Appendix V). The result is the Design Energy Consumption of the building, which can then be compared to its Design Energy Budget which, as noted previously, also incorporates these weighting factors.

The above calculation methods, fixed parameters and procedures define the Standard Evaluation Technique for this proposed rule.

4.4 Alternate Evaluation Techniques

Proposed § 435.03 permits the use of an approved alternate evaluation technique to calculate a building's Design Energy Consumption. DOE encourages the development and application of energy calculation methods, whether proprietary or in the public domain. DOE believes it to be in the public interest that additional computer and "manual" energy calculation methodologies be established as alternate evaluation techniques on a national basis.

DOE feels that the development of manual calculation methods is important because they will provide alternative procedures which are less costly and time consuming for calculating residential and small commercial building Design Energy Consumptions.

4.4.1 Proposed Procedure for Approval of Alternate Evaluation Techniques

There is little practical experience in establishing a testing methodology for determining equivalency between energy calculation methods. To date, only the State of California has established a certification procedure for computer energy calculation methods, and it has less than two years of regulatory and administrative experience with this process.

Proposed § 435.06 prescribes a procedure under which a request may be made to DOE for approval of an alternate energy calculation computer program or a manual energy calculation technique.

DOE intends to provide the applicant with standard data for several buildings, including drawings and specifications and other information as necessary. DOE feels that the input, and any assumptions that were made when completing the input, will be consistent with the Standard Evaluation Technique for all candidate methodologies considered.

The applicant would then perform the calculations using the candidate methodology. Changes to the input would not be allowed without DOE's permission. Using the results, the applicant would complete standard forms to be provided by DOE, which would then be returned to DOE together with copies of the applicant's data, specifications, the candidate methodology's normal results for these designs, and commentary on any variance from the standard data above. Approval will be granted by DOE if the results of the methodology are within an established range of the Standard Evaluation Technique acceptable to DOE.

DOE may also provide limited and qualified approval of an alternate evaluation technique. Such limitations and qualifications could include specific building types, geographic regions, and HVAC systems to which its application is restricted. Subsequent application of the approved alternate to the calculation of Design Energy Consumption would also include the use of the appropriate criteria and procedures established by DOE for all evaluation techniques. Should the candidate program methodology be disapproved, the applicant will be informed of the reasons.

Any changes in an approved alternate evaluation technique would be required to be reported to DOE. A decision will be made by DOE whether the changes would affect DOE approval of the alternate evaluation technique. Periodic checks of procedures or of results for reproducibility may be requested by DOE. A current list of approved alternate evaluation techniques along with any limits in their applicability will be published as Appendix III of the proposed rule. It is also anticipated that periodic updates of this listing will be published in the **Federal Register**.

4.5 Technical Issues

4.5.1 General Limits of Energy Calculation Methods

Energy calculation methods are sets of mathematical equations approximating the energy requirements and processes of a building, its components and systems, in response to both its use and to weather conditions. These methods are used during the design of a building to estimate its expected level of energy use. Since the calculation methods contain assumptions and approximations of the weather conditions, the projected building use, and the building's systems and components, it is difficult to predict exactly the building's actual performance. Results can be expected to be within ±15% of a building's actual energy consumption. With respect to HVAC systems, there are many important components and subsystems which affect energy consumption and that are imperfectly understood. However, the equations representing these are reasonably accurate. (See Technical Support Document No. 1, The Standard Evaluation Technique.)

In other areas, such as passive solar cooling, natural illumination and building infiltration, little quantitative information is known about all the factors affecting these processes.

4.5.2 Limits of the Standard Evaluation Technique Computer Programs

In addition to the generic limitations of computer programs, there are certain limitations specifically associated with each of the three Standard Evaluation Technique computer programs (see Technical Support Document No. 1, The Standard Evaluation Technique). At this time, DOE does not feel that a public domain methodology is available that can adequately evaluate the following categories of building types and HVAC systems:

- Single-family residential hybrid solar energy systems.
- All commercial unitary systems.
- Central-system commercial buildings which utilize passive or hybrid solar energy systems.

Because of these limitations, discussed more fully in Technical Support Document No. 1, DOE recognizes the need for evaluation technique exceptions as part of the administrative review procedures for the Standards. In those circumstances where the Standard Evaluation Technique cannot adequately analyze a building design or certain of its components, DOE is considering the establishment of a review process to determine whether Design Energy Consumption is less than or equal to the Design Energy Budget.[56] However, in the time period between this proposed rule and the final rule, DOE efforts will be aimed at developing a more comprehensive Standard Evaluation Technique than is currently available. The following matrix indicates how the Standard Evaluation Technique capabilities are planned to be expanded.

[56] Technical Support Document No. 1, The Standard Evaluation Technique, identifies different systems and technologies which the Standard Evaluation Technique is unable to treat at this time.

Building category	Coventional systems	Passive solar	Hybrid solar	Active solar
Single-Family Residential	DOE-2	DEROB	DEROB/TRNSYS	DOE-2/TRNSYS.
Commercial, Unitary	DOE-2	DOE-2	DOE-2/TRNSYS	DOE-2/TRNSYS.
Commercial, Central	DOE-2	DOE-2	DOE/2/TRNSYS	DOE-2/TRNSYS.

As depicted, the Standard Evaluation Technique capabilities will be expanded to encompass the currently expected building type and generic HVAC system categories for the final rule. Further, DOE is planning to develop a single computer program which will be applicable in all categories. This program, to be designated "DOE–n," is in the very early planning stages and requires considerable research and development work.

4.6 Public Comment

4.6.1 Comments on the ANOPR

Seventeen comments received by DOE after publication of the ANOPR addressed the issue of evaluation techniques. These comments related primarily to three different recommendations: (1) Specify one evaluation technique; (2) permit optional evaluation techniques; and (3) provide no evaluation technique.

The first group of comments (which were the majority received regarding this issue) encouraged the use of one evaluation technique that can be readily and accurately applied by both design professionals and building code officials to compute Design Energy Consumption. It was suggested that computer programs that would satisfy this prerequisite included DOE–1 (one comment), BLAST (two comments), ESP–1 (one comment), and AXCESS (one comment).[57]

The second group of commenters stressed that the evaluation techniques provided should be broad enough to permit the use of any recognized calculation procedure, and urged that both manual and computer based forms of calculation be made available. These comments maintained that design professionals should be permitted to select the methodology most appropriate to their needs. One comment urged that a reference list, covering manual and computer assisted techniques, be included in the rule.

The third group of comments questioned the ability to use available computer programs to estimate accurately actual building performance. Because the computation process can be quite complex, these comments were concerned with the lack of skilled technicians to prepare the design parameters of a building design for the computer programs. These comments urged that evaluation techniques such as DOE–1 not be included in the proposed rule, or, if included, be an optional evaluation technique.

4.6.2 DOE's Response

DOE shares the basic concerns raised by commenters to the ANOPR and has taken those comments into consideration in determining which approach to take for the evaluation technique. As proposed, a Standard Evaluation Technique is provided which meets DOE's criteria for the role which an evaluation technique must play in the performance approach under these Standards. Additionally, an approval process for alternate evaluation techniques is proposed which allows limited and qualified approval for both computer based and manual energy calculation methods. Therefore, DOE foresees that a wide variety of energy calculation methods will be developed to determine a building's Design Energy Consumption that will yield results consistent with the Standard Evaluation Technique.

4.7 General Issues

DOE's objectives in the development of the evaluation technique concept in general, and the Standard Evaluation Technique in particular, have been:

(1) Accuracy: To select an energy calculation method that is representative of the current state of the art for such methods.

(2) Replicability: To assure an acceptable degree of consistency of results among evaluation technique users through the use of certain fixed data parameters and building operating conditions.

(3) No undue burden: To minimize undue economic, time or training burdens on designers using evaluation techniques for compliance with the Standards, and to facilitate the use of evaluation techniques at the appropriate level of detail and cost which accommodates the designs of both large, complex buildings, and small, uncomplicated ones.

(4) Innovation: To permit and encourage the use and evaluation of innovative energy conserving design strategies.

Considering the complexity of developing and using evaluation techniques and the limits to the current state of the art of calculation methods, these objectives are difficult to attain at once. Further, the four objectives may tend not to support one another. For example, the evaluation technique utilizes the fixed parameters and procedures so that an aceptable degree of replicability of results can be obtained. However, the use of Standard Building Operating Conditions may not encourage innovation because it may restrict the application of energy conserving design strategies that rely on reasonable temperature swings in response to external climate conditions. This is an especially sensitive issue with respect to passive solar buildings. The use of fixed parameters may also cause undue burdens for building designers in that a duplication of effort will result when energy calculations are performed using both the hours of operation actually expected for the building design and those required by the Standards.

DOE is aware of the potential for certain inequities to arise from conditions similar to the examples given above. Currently, DOE is seeking ways to attain all of its objectives with the evaluation technique and not stifle innovation or cause undue burdens to building designers. The solution may well lie with the development and approval of alternate evaluation techniques.

DOE's ongoing research program is geared to enhancing the capabilities of the Standard Evaluation Technique computer programs to model additional innovative and traditional systems. Efforts are also underway to make the Standard Evaluation Technique significantly easier to use. In addition, DOE is actively supporting the development of simplified energy calculation methods, in the public domain, which will use programmable calculators or microcomputers (see Technical Support Document No. 1, The Standard Evaluation Technique). DOE also encourages the development and approval of simple, easy-to-use proprietary evaluation techniques.

DOE recognizes the need for an exceptions procedure for innovative building designs which cannot be evaluated by approved evaluation techniques. Further, DOE is concerned that such an exceptions procedure not cause costly time delays that could act as a deterrent to the use of innovative techniques in complying with the Standards.

[57] DOE–1 is an earlier version of DOE–2. BLAST is an energy program developed by the Corps of Engineers Research Laboratories and is in the public domain. ESP–1 is a proprietary program of Automated Procedures for Engineering Consultants (APEC).

DOE feels that the four objectives of accuracy, replicability, no undue burden and encouraging innovation also apply to the development of the proposed procedure for approving alternate evaluation techniques.

Issues related to the approval process include:

• Development of abbreviated formats for weather data, fixed parameters, operating conditions and procedures appropriate for simpler calculation methods.

• Development of procedures for approving evaluation techniques which include capabilities not present in the Standard Evaluation Technique.

• Development of straightforward updating procedures to approve enhancements and refinements to approved evaluation techniques.

DOE is especially concerned that the approval process not result in undue cost and time burdens on smaller oganizations with special evaluation techniques.

4.8 Relationship to Actual Consumption

DOE anticipates that many questions will arise concerning the consequences of not complying with the proposed Standards once they are in effect. For example, DOE officials have been asked: What will happen if a particular building's actual energy consumption, after its construction and "break-in" period, exceeds its Design Energy Budget? The intent of these Standards is to regulate only the designs of new buildings. The operation of buildings is not within the scope of the Standards as proposed.

Also, evaluation techniques may provide a reasonable projection of expected building energy use under standard conditions, but it is not a precise prediction of actual use because:

• Approximations and assumptions are used by all energy calculations methods (see Section 4.5.2 and Technical Support Document No. 1, The Standard Evaluation Technique).

• Historical weather data from a previous reference year is used, which will vary from the weather for each year that the building is in actual operation.

• The Standard Building Operating Conditions used to provide a consistent comparison of Design Energy Consumption among buildings with the same uses may be different from the actual use of a particular building over a year's time.

• The Design Energy Consumption calculation excludes energy for certain process uses, such as computer operations, kitchen equipment and laundries; however, the actual energy used by the building would include these energy uses.

4.9 Request for Public Comment

Because of the significance of the evaluation technique concept, DOE is especially interested in receiving public comment on issues related to the Standard Evaluation Technique and the approval process for alternate evaluation techniques.

5.0 Implementation

5.1 Introduction

This discussion of the implementation of the Standards is included to offer the public as complete a picture as possible of the operation of the program as it is presently conceived. This is done to facilitate comment on the proposed Standards, in addition to providing a basis for comment on issues specifically related to the development of implementation regulations. A proposed rule on implementation will be published at a later date.

Comments received from the Advance Notice of Proposed Rulemaking published by HUD in November 1978, revealed a concern by State and local officials that sanctions might be imposed before they have sufficient time or resources to come into compliance with the Standards. For this reason, several implementation alternatives are being considered to address any burden placed on State and local code officials by implementation of the proposed rule.

The Act authorized HUD to develop and promulgate energy performance standards for new buildings and to undertake the implementation of such standards. The Department of Energy Organization Act, enacted in August 1977, transferred from HUD to DOE the responsibility and authority to develop and promulgate the Standards. HUD currently has statutory responsibility for issuing implementation regulations.

Both HUD and DOE recognize that the development of implementation regulations, prescribing how compliance with the Standards is to be achieved, is closely linked to the development of the Standards themselves. Therefore, on March 21, 1979, a Memorandum of Understanding (MOU) was executed by HUD and DOE, pursuant to which DOE agreed to prepare analyses of implementation issues and to undertake development of administrative procedures in connection with implementation.

This section of the preamble is based upon the analyses and implementation issues development performed by DOE in discharging its responsibilities under that MOU.

5.2 Statutory Requirements

Section 305(a) of the Act provides that "no Federal financial assistance shall be made available for the construction of any new commercial or residential building in any area of any State" unless certain actions are taken by State and local governments to avoid imposition of the sanction. "Federal financial assistance" is defined in Section 303(7) as:

(A) Any form of loan, grant, guarantee, insurance payment, rebate, subsidy, or any other form of direct or indirect Federal assistance (other than general or special revenue sharing or formula grants made to States) approved by any Federal officer or agency; or

(B) Any loan made or purchased by any bank, savings and loan association, or similar institution subject to regulation by the Board of Governors of the Federal Reserve System, the Federal Deposit Insurance Corporation, the Comptroller of the Currency, the Federal Home Loan Bank Board, the Federal Savings and Loan Insurance Corporation, or the National Credit Union Administration.

Section 305(c) of the Act requires that each House of Congess must approve the need for the sanction before it comes into effect.

Under Section 305(a)(1) of the Act, a State may avoid imposition of the sanction by certifying that:

(A) The unit of general purpose local government which has jurisdiction over such area has adopted and is implementing a building code, or other construction control mechanism, which meets or exceeds the requirements of such final performance standards, or

(B) Such State has adopted and is implementing, on a statewide basis or with respect to such area, a building code or other laws or regulations which provide for the effective application of such final performance standards.

The Secretary is authorized by Section 305(a) to review and investigate the accuracy of, and to periodically update, such certifications. After providing notice to a State, and opportunity for a hearing, the Secretary may disapprove or require the withdrawal of a State certification.

As an alternative to Section 305(a)(1), Section 305(a)(2) of the Act permits the sanction to be avoided where new buildings are determined to be in compliance with the final energy performance Standards pursuant to an alternate approval process. "Approval process" is defined in Section 305(b)(3) to mean:

A mechanism or procedure for the construction and approval of an application

to construct a new building and which involves (A) determining whether such proposed building would be in compliance with the final performance standards for new buildings promulgated under section 304, and (B) administration by the level and agency of government specified by the Secretary pursuant to paragraph (4).

Section 305(b)(4) prescribes the unit of government which shall administer the approval process, in descending order of priority as follows: (1) The agency which grants building permits on behalf of the local governments with jurisdiction over the area in which new construction is proposed; (2) if such agency is not willing and able to administer the approval process, then the process shall be administered by any other agency of the local government with authority to administer the process which is willing and able to do so; and (3) if neither of such agencies is willing and able to administer the approval process, any agency of the State with authority to administer the approval process may do so. Under Section 305(b)(2), the Federal Government is given overall responsibility for an effective alternate approval process.

Section 305(a)(3) authorizes the Department to grant exemption from the enforcement of the sanction, at the request of a State, for areas where construction of new buildings is not of a magnitude to warrant the costs of the measures set forth in Sections 305(a) (1) and (2). Such an exemption may be rescinded where the Department finds that the level of new construction has increased sufficiently to warrant the costs of the alternate measures.

Other statutory provisions include Section 307 which authorizes the Department to make grants to States and local governments to assist them in meeting the cost of administering State certification procedures or an alternate approval process. Under Section 308, the Department is authorized to provide, directly or indirectly by contract or other methods, technical assistance to States and local governments to aid them in meeting the requirements of the Act. No funds have been appropriated pursuant to Sections 307 and 308.

Section 252 of the National Energy Conservation Policy Act (NECPA) (Pub. L. 95–619) requires that, when the performance Standards under this program are made effective, the Minimum Property Standards (MPS) of the Federal Housing Administration and the Farmers Home Administration shall be revised to meet those Standards. Even if Congress does not approve the use of the sanction, this provision means that, after the effective date, any new construction subject to MPS (all subsidized and Federally insured housing programs) must comply with the performance Standards. Section 306 of the Act requires that the head of each Federal agency responsible for the construction of any Federal building shall adopt procedures necessary to assure that any such construction meets or exceeds the performance Standards. Section 546 of NECPA further provides that energy performance targets are to be established for construction of Federal buildings which are consistent with the performance Standard levels set pursuant to the Act. These latter provisions are effective whether or not Congress approves the sanction provisions of the Act.

5.3 Considerations in Developing an Implementation Program

To be effective, the implementation of the Standards must be developed within the existing system for the regulation of building construction. Regulation of building construction has traditionally been a local prerogative exercised through local building codes. It has only been within the past decade that States have begun to assert their authority to control construction through the use of statewide mandatory building codes. In almost all cases, though, enforcement of the code has been left to the locality.

Standards used in building code regulations have traditionally been written in specification (as opposed to performance) terms.

Another important feature of the regulatory system is the need for technical assistance for building code officials if they are to adopt and implement the Standards. The concept of energy-related construction requirements is relatively new to many local building officials. Since local building officials often are not architects or engineers trained in building performance concepts, technical assistance will be needed if the long-term objective of performance based regulations is to be achieved.

Another characteristic of the code environment which may affect the design of any Federal regulatory program is the typically small size of code enforcement staffs and the multiplicity of their regulatory responsibilities (e.g., plumbing, electrical, elevator, etc.). In addition, local code enforcement offices may have limited fiscal resources to implement the program.

5.4 Implementation Approach

This discussion is intended to give the public a perspective on at least one approach to the implementation of the proposed Standards. This proposed rule does not include a proposed implementation rule. As mentioned earlier, a proposed regulation addressing implementation is expected to be issued in the near future.

The following sections discuss a preliminary approach to three implementation alternatives: State Certification, Alternate Approval Process and Exemptions.

5.5 State Certification

The Act makes it clear that the States, not the Federal Government, have the authority to certify whether a building code meets or exceeds the Standards. The Federal authority rests in the language in the Act which says this State certification authority is to be exercised in accordance with regulations promulgated by the Secretary, currently the Secretary of HUD.

DOE has considered what the form and substance of these regulations should be to achieve an effective Standards program.

An effective program would require that approved building codes meet certain minimum criteria. To insure this, the regulations should require that a State certify a building code only after it meets these criteria.

The minimum criteria might be:

(1) That the code is equivalent to or exceeds the requirements of the Standards, and

(2) That the building code jurisdiction has an adequate implementation program.

The regulations could require a finding by the State that these criteria have been met prior to the certification of a building code. The Secretary could require that a copy of this finding be sent to the Federal Government. This would facilitate the monitoring of the State certification program.

Section 305(a)(3) of the Act supports this type of monitoring program with the following language:

> The Secretary shall review and conduct such investigations as are deemed necessary to determine the accuracy of such certifications and shall provide for the periodic updating thereof. The Secretary may reject, disapprove, or require the withdrawal of any such certification after notice to such State and an opportunity for a hearing.

At first glance, the State certification of building codes would appear to pose special problems for a statewide code. A State is placed in the position of certifying its own code.

This problem may be more apparent than real. A State can be expected to take great care to certify a statewide code only if it is equivalent to or exceeds the requirements of the

Standards, because to do otherwise would jeopardize the financing of new building construction in the State.

The regulations should be adequate if the State certification of a statewide code is monitored in the same manner as a local code. The State would be required to make a finding that the statewide code meets the same criteria required of local codes and to provide a copy of this finding to the Secretary. The Federal Government could then review the State's finding to insure that it meets the criteria.

The determination of the equivalency of a building code to the Standards is a major requirement that probably is beyond the analytical capabilities of most States. DOE recognizes that it will have to provide technical assistance to the States to help them meet this requirement.

To be equivalent, a building code would have to satisfy one of the following requirements:

(1) The code must be identical to one of the model codes, model equivalent codes or standards, or manuals of recommended practice approved by DOE and listed in Appendix IV of the Standards, or

(2) The code must provide that a building design meets or exceeds the requirements of the Standards.

To simplify the State task of certifying codes, DOE intends to prequalify, to the extent feasible, standards and codes for inclusion in Appendix IV prior to the effective date of the Standards. Local jurisdiction and States would then be able to adapt or model their codes after one of these equivalent approaches.

DOE is considering making available a methodology for evaluation of a code, with an accompanying administrative manual to States choosing to certify codes. This methodology would provide objective criteria by which codes could be measured against the Standards, thereby facilitating States making equivalency determinations.

Where a State does not have the technical or financial capacity to make equivalency determinations, it could submit the codes of local governments to the Secretary for an "advisory opinion." This would be an informal method of determining whether a code was equivalent to the Standards before the locality has expended funds for adoption and enforcement procedures.

DOE has considered how this regulatory approach could fit into a workable Standards program. To accomplish this, it is important that lending institutions and the other Federal agencies responsible for applying the sanction have current and reliable information on where building codes have been certified.

The regulation could require monthly reports from the States on the building codes they have certified, along with the State findings supporting the certification of these codes, as discussed above. The Secretary could then publish a list of certified codes every month in the **Federal Register.**

The lists of certified codes could then be referred to by lending institutions and other Federal regulatory agencies responsible for imposing the sanction. Once the name of the State or local code jurisdiction was published in the **Federal Register,** and so long as the certification remained valid, no sanction would be imposed against applicants for Federal financial assistance who had designed their buildings to a certified code in those jurisdictions.

DOE has also considered additional ways in which the Federal Government may assist the States and local governments in their administration of the Standards program. The existing State Energy Conservation Program could be used as a mechanism for providing this assistance. This program was initiated by the Energy Policy and Conservation Act (EPCA) of 1975, 42 U.S.C. 6321 *et seq.*

The EPCA program provides grants to States that undertake energy conservation programs which must include certain mandatory provisions, including the adoption and implementation of building lighting and thermal efficiency standards.

Through this program, the States have made rapid progress toward regulations that require more energy efficient new building construction. As indicated in Technical Support Document No. 6, Draft Regulatory Analysis, 34 States have enacted codes that cover all or a portion of their new private construction and an additional 10 States require that code provisions be met in new State construction. An average of $50,225 per year was spent by the 50 States in FY–1978 in adopting and implementing EPCA building standards.

The Administration is supporting the proposed Energy Management Partnership Act of 1979 which is now before Congress. This act would enlarge the capacity of the States to implement the Standards program. The act would increase the Federal funding for State programs, including building code programs, and require additional coordination between State and local governments.

The regulations implementing the Standards could be incorporated into these existing programs and proposed new legislative authorities. This would help insure coordination between the implementation of the Standards and other State energy conservation activities.

In addition to the basic requirements that must be met before a code is certified, DOE has identified other possible features that could be required in order to achieve the goals of the Standards program.

The first is that designs for buildings in excess of 50,000 gross square feet would have to be evaluated and certified by a qualified design professional using an approved evaluation technique. It is expected that projects of this size are best analyzed in this way due to the complexity of the relationship of different components and the opportunity to employ performance type energy conserving design concepts. Because these designs customarily require the services of architects or engineers, the requirement should not constitute an undue added burden.

The second requirement would be that each State or local building code contain a procedure whereby an applicant could qualify the design of a building using a performance approach. This requirement would not preclude a State from certifying building codes that use a prescriptive or component approach, but it would ensure an opportunity for a designer to evaluate a whole-building design using a performance path. When the Energy Budget Levels are provided in advance, design costs using the performance path may be less costly than the current practices required by many codes.[58] Training and exposure to performance based design would permit and encourage the opportunity for the increased use of whole-building performance standards.

The third requirement is that a State certified code make certain that a building permit, or an occupancy permit, is not issued for a building where a building design does not satisfy the energy section of the code. The energy section must have the same enforcement standing as other sections of the code, such as health and safety.

The fourth requirement is the need for periodic inspections of the building as it is being constructed, to assure that it is being constructed in conformance with the approved designs.

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[58] Many codes applicable to commercial buildings are based upon the ASHRAE 90–75 Standard. This standard requires that, before the performance approach for designing a building can be utilized, the building must be designed using the component approach. This step is necessary to determine applicable budget numbers. When the budgets for particular buildings are provided in advance, as they are in the Standards, a designer need not go through the component design procedures, thereby reducing design costs.

For various reasons, a code may not cover all building types specified in the Standards. Some types may be regulated by separate codes. For example, a State may have a specific code for the construction of schools or hospitals. As part of the certification of a code, the State would have to identify which building types are not covered by the certification and how the Design Energy Consumptions of those building types are regulated.

Sanctions could still be imposed where a particular building design is not covered by a certified local code, unless there is a different certified code covering that particular building type. An example illustrating this problem would be where a local code does not cover schools or hospitals. In this case, the proposed building would either have to be designed in conformance with a certified State energy code for schools and hospitals, or qualify under an alternate approval process as discussed below or, the designs would otherwise have to be determined to meet or exceed the requirements of the Standards.

An important issue in the development of State certification procedures concerns amendments to certified building codes for which determinations of equivalency have been issued. States would be required to notify the Secretary of any amendment to a certified code, if such amendment may affect the energy performance of building designs.

When the Standards requirements themselves are revised, an issue arises as to the need to reexamine codes to determine their continued equivalency. In this case, the Secretary would notify States of any amendments required of certified codes due to revision of the Standards. However, the certified codes would remain in effect during a specified period allowed for adoption of the required amendments. An alternative approach would be to require the resubmission of the State plans with new certifications whenever the Standards requirements are revised.

5.4.2 Alternate Approval Process

A second path for complying with the Standards and thereby avoiding the imposition of the sanction would be to satisfy the alternate approval process requirements of the Act.

The term "approval process," as used in Section 305(b)(3) of the Act, means "a mechanism and procedure for the consideration and approval of an application to construct a new building and which involves (A) determining whether such proposed building [is] in compliance with the . . . standards . . ."

The approval process is a means of determining the compliance of a building design with the Standards in the absence of a certified State or local code. The expectation is that, at least for the period immediately following the effective date of the Standards, the approval process may be used by local governments more frequently than the certified code path.

There are several reasons for this:

(1) Some time may be required to bring a local code into equivalence with the Standards.

(2) There may not be adequate implementation of a code to obtain a certification.

(3) Some local code enforcement offices may not have the technical capacity to implement a certified code, even though code provisions meet or exceed the energy requirements of the Standards.

(4) Some communities currently have not energy or building codes operating in their jurisdictions.

The alternate approval process as presently conceived would require two steps to approve an application to construct a new building:

(1) A determination that the building desing meets or exceeds the requirements of the Standards.

(2) A declaration by an appropriate level of local or State government that the requirements of the Standards have been met.

The determination could be made by a local code enforcement agency or a private design professional. Many local code enforcement agencies in the country will have the internal capacity to review designs and make these design equivalency determinations. DOE is considering making available a number of evaluation and design aids to facilitate and assist local enforcement agencies in making these determinations. These aids will include a list of prequalified codes against which designs can be compared, manual calculation methods, manuals of recommended practice, and other model codes and standards in formats with which code officials are familiar, in addition to more sophisticated computer evaluation techniques described in other sections of this preamble.

A local code enforcement department which issues a building permit after making a compliance determination could be regarded as administering an approval process. An appropriate official would have to make a declaration to the permit applicant that the building design complies with the Standards. This declaration by an appropriate official with authority to issue building permits could fulfill the administrative requirements of the approval process.

Even with these tools, many local governments may not want to evaluate building designs. Therefore, the approval process would permit qualified design professionals to certify that a building design satisfies the energy requirements of the Standards. This certification could also meet the determination step of the alternate approval process.

The design professional may be a licensed architect or engineer, code official, or member of any related professional group. Since the approved methods of showing equivalency in Appendix IV of the proposed rule will vary, the required skills of the design professional will likewise vary. The more sophisticated design analysis will require a more highly trained professional. Therefore, it is anticipated that, for each equivalent method included in Appendix IV, there will be an accompanying listing of requirements that, if satisfied, would qualify a design professional.

The certification by a qualified design professional would require a determination by the professional that the Design Energy Consumption of a building design does not exceed the applicable Design Energy Budget for that building type. The qualified design professional could follow the Standard Evaluation Technique or any procedure given in Appendix III.

In addition to the determination that the building design meets the requirements of the Standards, the alternate approval process would also require a declaration by a local or State agency that the requirements of the Standards have been met. Section 305(b)(4) of the Act defines and prioritizes different administering agencies. It gives a priority ranking for administration, starting with an agency that grants building permits on behalf of the unit of local government, then to another local agency, and ending with a State agency. The authority would go to the highest priority agency willing and able to administer the approval process.

The administering agency would be required to include specific findings in its declaration that the administrative requirements of the Standards have been met. These might include:

(1) The administering agency has authority to administer the approval process.

(2) It has received a copy of the building design and a copy of the certification issued by the qualified design professional for that building design.

(3) The person applying for the declaration has provided a written assurance to the agency that construction of the building will conform to the submitted design and that, should substantial modifications occur during construction, a recertification based upon the final design will be submitted.

This approach would not necessarily involve the administering agency in the actual "determination" of the building design, but it would be the focal point where the approval process could be administered.

To avoid the sanction, an applicant for construction funds would present this declaration to a lending institution or other appropriate Federal regulatory agency to show compliance with the Standards.

5.6 Exemption

It is anticipated that most State and local jurisdictions will be able to avoid imposition of the sanction in a cost-effective manner through the adoption and implementation of State-certified building energy codes or the use of the alternate approval process. However, Congress recognized there may be areas of the Nation where the volume of building construction is so low and building regulatory mechanisms so undeveloped that the approval process, or adoption and implementation of State-certified codes, would be disproportionately costly in relation to the benefits expected to be obtained. Section 305(a) of the Act provides for the grant of an exemption to such areas.

A request for exemption would include data from which a cost-benefit analysis could be performed. The State would estimate the cost of administering an approval process based upon the anticipated levels of construction in that area. Those costs would be subtracted from a dollar estimate of the benefits in energy savings that would be achieved over the same period had buildings been designed in accordance with the Standards. If the balance is negative (i.e., costs exceed benefits), an exemption would be granted.

Further, no exemption would be granted to an area within a State which is located within a code enforcement jurisdiction. The existence of an agency to regulate building inspection in those areas indicates that the level of construction in such areas is sufficiently high to justify the cost of regulation.

The exemption, or an extension of an exemption, could be effective for a specified period. This limitation would provide assurance of a periodic review and assessment of the exemptions granted. Further, the Secretary is authorized to rescind a grant of exemption whenever he finds that the level of building construction has increased or other circumstances have changed, so that implementation is feasible and the costs of implementing the Standards are warranted (Section 305(a) of the Act).

5.7 Impact on Financing New Construction

Assuming the imposition of sanctions, the Act would affect those who provide Federal financial assistance, including lenders, by prohibiting the use of funds for construction of buildings whose designs are not in compliance with the Standards.

The goal would be to define, as unambiguously as possible, when a construction loan or commitment would be subject to the sanction.

The Federal Government could publish periodically in the **Federal Register** the current list of exempt jurisdictions and jurisdictions with certified codes. The lender would then need to determine whether the jurisdiction within which the building is to be constructed is on either list. If it is, no further requirements would be attached to the financing to comply with the Standards. If the jurisdiction is not on either list, the lender would have to obtain the declaration by the agency administering the alternate approval process discussed above to qualify for financing.

The analysis and development of the implementation issues in this section of the preamble are presented by DOE as a possible approach for achieving compliance with the Standards. To repeat, the intention of this section is only to provide the public with a perspective on how the Standards might be implemented. Specific implementation rules will be proposed at a later date.

6.0 Other Matters

6.1 Environmental Review

As required by Section 7(c)(2), 15 U.S.C. 766(c)(2) of the Federal Energy Administration Act of 1974 (15 U.S.C. 761 *et seq.*), a copy of this proposed rule was submitted to the Administrator of the Environmental Protection Agency for comments on the impact of this proposed rule on the quality of the environment. The Administrator to date has expressed no comment.

A Draft Environmental Impact Statement (DEIS) was prepared in accordance with the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*). The DEIS has been designated Technical Support Document No. 7 and is available to the public for comment as noted at the beginning of this preamble. This document also discusses indoor air quality.

6.2 Regulatory Analysis

DOE has determined that this proposed rule is significant and is likely to have a major impact. Accordingly, a Draft Regulatory Analysis and a Draft Urban Impact Analysis have been prepared in addition to the environmental analysis discussed in Section 6.1.

A summary of the Regulatory Analysis which is published below, and supporting documentation, consists of (1) an extensive statement of the problem addressed by the regulation, and the mandate for government action; (2) a description and analysis of the reasonable and feasible policy alternatives to meeting that mandate, including the legislative authority, institutional and other impacts of the standards; and (3) a comparative analysis of the impacts of the alternatives, quantified when possible.

The discussion in (3) also contains an analysis of the effects of the alternatives on: The objectives of national energy policy or energy statutes; the economic well-being of the Nation as a whole, individual industries, levels of government, geographic regions, and demographic groups; compliance and other requirements; competition; other relevant costs and benefits; and the fairness of the distribution of the costs and benefits.

The Draft Regulatory Analysis Summary, published in this section, contains a discussion of:

- Problem and Mandate for Government Action
- Policy Objectives
- Projected Economic Effects of the Proposed Standards
- Major Alternatives Considered
- The Proposed Approach, and the Reasons for Choosing the Preferred Alternative

The Urban Impact Analysis examines the possible impacts of a proposed program on cities and communities in terms of employment and labor category demand.

The Draft Regulatory Analysis and Draft Urban Impact Analysis are contained in Technical Support Document No. 6, which will be available for public comment as noted at the beginning of this preamble.

This action is in accordance with Executive Order 12044, "Improving Government Regulations," May 1, 1978, 43 FR 18634; DOE Order 2030, "Procedures for the Development and Analysis of Regulations, Standards, and

Guidelines," January 3, 1979, 44 FR 37779; and OMB Circular A–116, "Agency Preparation of Urban and Community Impact Analyses," August 16, 1978, 43 FR 37779.

6.2.1 Problem and Mandate for Government Action

As a basis for the Energy Conservation and Production Act (the Act), Pub. L. 94–385, Congress found that "* * * large amounts of * * * energy are consumed unnecessarily each year in [new] residential and commercial buildings because such buildings lack adequate energy conservation features." (Section 302(a)). To reduce this energy waste, the Act mandated the development and implementation of performance standards for these buildings (Section 302(b)).

One of the major reasons for both Congressional and DOE action is the recognition that over one-third of all energy consumed in the United States is used for space conditioning, lighting and domestic hot water in buildings. This is about the same amount of energy that is imported by the Nation. However, at least 40% of the energy consumed by buildings is wasted because of inefficient building design and equipment.

6.2.2 Policy Objectives

The Act calls for the promulgation of performance standards to achieve in buildings the maximum practicable increases in energy conservation and in the use of renewable resources. Performance standards, as defined by the Act, specify energy consumption goals for buildings without specifying the methods, materials or processes to be used in achieving those goals. The Act also directs that the Standards take account of climatic variations across the Nation, and that they be adequately analyzed in terms of energy efficiency, stimulation of use of nondepletable sources of energy, institutional resources, habitability, economic cost and benefit and impact upon affected groups.

As discussed in detail in Section 2.4.2 of the preamble, the Standards as proposed are projected to promote the use of renewable energy sources, particularly solar energy for heating, cooling and domestic hot water. This would further the Solar Heating and Cooling Demonstration Act of 1974 (Pub. L. 93–409, 43 U.S.C. 5501 *et seq.*) and the Solar Energy Research, Development and Demonstration Act (Pub. L. 93–473, 42 U.S.C. 5551 *et seq.*), whose goals, in part, are to encourage the use of solar energy and other renewable energy resources in buildings.

6.2.3 Projected Economic Effects of the Proposed Standards

DOE finds that the proposed Standards will require new buildings to reduce their design energy requirements by 17% to 52% from 1975–1976 levels, depending on the building type. Energy savings from the Standards are projected to be 0.22 quads annually (0.1 million barrels per day of oil equivalent, MBDOE) by 1985, and 0.46 quads annually (0.2 MBDOE) by 1990. This is in addition to the energy saved by other building energy efficiency improvement programs. The cumulative energy saved between 1980 and 2020 is projected to be 29 quads.[59]

Employment is projected to increase through additional investment in building conservation. It is expected that, cumulatively, 48,000 additional jobs will be created in 1980, 86,000 in 1985, and 70,000 in 1990. The short-term impact on inflation is near zero. Over the long term, the Standards will decrease the rate of inflation by reducing the impact that increased energy prices have on building owners.

Urban impacts were investigated for selected SMSA's in terms of changes in population growth, construction and employment. Employment was analyzed in terms of utilities, services and the construction industry. Employment in the utilities sector was projected to decrease, while that in services and construction was projected to increase in the SMSA's studied.

6.2.4 Major Alternatives Considered were:

- No Federal action to implement the Standards.
- Implementation of less stingent Standards.
- Implementaion of more stringent Standards.

The alternative of not implementing the Standards assumes that all improvements in building energy efficiency would come from existing standards such as the HUD Minimum Property Standards or ASHRAE 90–75, from a reaction to rising energy prices, or from independent State and local government action. For comparison, the proposed Standards are projected to use 29 quads less energy than this alternative would between 1980 and 2020. The value of energy saved by implementing the Standards, less increased building construction costs and increased implementation costs, is expected to have a net present value of $6 billion (evaluated in constant 1978 dollars, using a 10% real discount rate).

Using less stringent Energy Budget Levels, 10.5 quads of energy would be saved between 1980 and 2020 and the national net present value is $3 billion (1978 dollars). For the more stringent alternative, cumulative energy savings would be 55 quads, with a national net present value of $3 billion (1978 dollars).[60]

It should be mentioned that more stringent Energy Budget Levels for commercial and multifamily residential buildings, coupled with the proposed Energy Budget Levels for single-family residential buildings, taken together as a single alternative, is projected to conserve 44 quads of energy and have a national net present value of $7.3 billion. However, DOE determined that the more stringent commercial and multifamily residential Energy Budget Levels exceeded the limits of current knowledge of most designers and would therefore be difficult to achieve in practice.

Other alternatives considered different types of standards, including:

- Use of component, rather than whole building, performance standards.
- Performance standards based on actual, rather than design, energy consumption.
- Energy prices set at levels which would result in savings equal to those of the Standards.
- Information and education programs only.

The use of component, rather than whole building, energy performance standards could possibly entail lower implementation and enforcement costs because many States have already legislated such an approach. However, the performance approach permits the designer to analyze the building as a total system and choose the most cost-effective techniques available to produce an energy efficient building. Furthermore, the use of innovative design techniques is stimulated through the use of the whole building, rather than the component, approach.

[59] The figures presented are based on the proposed Energy Budget Levels and are for net present values and energy savings which include only those building classifications contained in the proposed rule. Restaurants, industrial buildings and mobile homes are excluded. Key assumptions in the analysis are: (1) no updates of the Standards, and (2) the base case (no Federal action) has increasing levels of energy conservation in response to rising energy prices and the commercialization of new energy conservation technology (corresponding to 40% penetration of the HUD Minimum Property Standards for One- and Two-Family Dwellings, by 1980, held constant thereafter, and 62% penetration of ASHRAE 90–75 by 1980).

[60] The net present value for the stringent alternative declines compared to that of the proposed Standards, in spite of the greater energy savings. This decline occurs because the added cost of the conservation measures exceeds the value of the additional fuel savings.

Performance standards based on actual, rather than design, energy consumption would require a completely different enforcement approach. Enforcement officials would need to determine, directly or by inference, actual energy consumption for individual buildings. This alternative could have the greatest impact on the manner in which building occupants use energy. It would also tend to promote the use of renewable resources in much the same way as the proposed Standards. However, enforcement would be more difficult since local officials would have to contend with the varying ways in which different occupants utilize buildings.

Setting energy prices so as to produce energy savings equal to those of the proposed Standards is possible, but it could place a significant burden on owners of older, less energy-efficient buildings and on low-income citizens who are least able to bear the increase in cost.

The information and education alternative would require that the public exert the demand for energy efficiency in new buildings. It would also require the education of design professionals in the use of energy efficient design techniques. A program to inform and educate consumers and design professionals on the energy and cost consequences of different materials and building design strategies would have to be on a national scale and a long-term basis. It is considered unlikely that a public education program alone could achieve the same energy savings as the proposed Standards.

Comments are invited on the alternatives considered, and on any others which the public feels should be analyzed in the final Regulatory Analysis.

6.2.5 The Proposed Approach

Under the proposed approach, the Design Energy Consumption of a building is determined from its design, an assumed set of operating conditions and pertinent climate factors.

The proposed Standards specify Energy Budget Levels interms of building design classification, heating fuel type (single-family residences only) and climate conditions. A building design is in compliance with the Standards if its Design Energy Consumption does not exceed the Design Energy Budget specified for its design classification and climate conditions.

The Energy Budget Levels in the proposed Standards are technologically achievable, would conserve substantial amounts of energy compared to current building designs, and would achieve a net economic benefit both to the Nation and the building owner.

7.0 Opportunities for Public Comment

7.1 Written Comment Procedures

Interested persons are invited to participate in this rulemaking by submitting data, views, and comments to Joanne Bakos, Office of Conservation and Solar Energy, Department of Energy, Docket Number CAS–RM–79–112, Mail Station 2221C, 20 Massachusetts Avenue, N.W., Washington, D.C. 20585.

Comments should be identified on the outside of the envelope, and on the documents themselves, with the designation, "Energy Performance Standards for New Buildings, Docket Number CAS–RM–79–112." Fifteen copies should be submitted. All comments received on or before February 26, 1980, and all other relevant information will be considered by DOE before final action on this rule.

Any person submitting information which that person believes to be confidential and which may be exempt by law from public disclosure should submit one complete copy, as well as fifteen copies from which the information claimed to be confidential has been deleted. DOE shall make a determination on any such claim. This procedure is set forth in 10 CFR 1004.11 (44 FR 1908, January 8, 1979).

7.2 Public Hearings

DOE will hold five public hearings on this proposed rule and the Technical Support Documents, including the Draft Environmental Impact Statement. The hearings will be held at 9:30 a.m., local time, on the dates and at the locations given in the table at the beginning of the preamble.

Any person interested in this proposed rule or any person who is a representative of a group that has an interest in this proposed rule may make a written request to speak at the hearings. All such requests must be received by the date indicated for each hearing in the table at the beginning of the preamble. Requests should be sent to Joanne Bakos at the address given above. A request may be hand-delivered between the hours of 8:00 a.m. and 4:30 p.m., Monday through Friday, except Federal holidays. Requests should be marked the same as for written comments, with the additional notation, "Request to Speak."

The person making the request should briefly describe that person's interest and, if appropriate, state why that person is a proper representative of a group. The person should also give a concise summary of the proposed oral presentation and should provide a phone number where the person may be reached. Each person selected to be heard will be notified by DOE by the date indicated for each hearing. Those persons selected to be heard must bring fifteen copies of their statements to the hearing. If any person cannot provide fifteen copies, alternate arrangements can be made in advance of the hearing. This should be done in the letter requesting to speak, or by contacting Joanne Bakos at 202–376–1651.

7.3 Conduct of the Hearings

DOE reserves the right to select the persons to speak at the hearings, to schedule their presentations, and to establish the procedures governing the conduct of the hearings. The length of time for each presentation will be limited, based on the number of persons requesting to speak.

A DOE official will preside at each hearing. These will not be judicial or evidentiary type hearings. Questions may be asked of speakers only by those conducting the hearing, and there will be no cross-examination of persons presenting statements. Any decision by DOE on the subject matter of a hearing will be based on all the information available to DOE. At the conclusion of all initial oral statements, each person who has spoken will be given the opportunity to make a rebuttal statement, if desired. The rebuttal statements will be given in the order in which the initial statements were made and will be subject to time limitations.

Any interested person may submit questions to be asked of any speaker. DOE will determine whether the question is relevant and whether the available time permits it to be presented. The questions should be received at the following addresses by the last working day prior to the hearing: Washington, D.C., hearing: Joanne Bakos, Office of Conservation and Solar Energy, Mail Station 2221C, 20 Massachusetts Avenue, N.W., Washington, D.C. 20585 (202–376–1651); Kansas City, MO, hearing: Suzanne Mathews, Department of Energy, 324 East 11th St., Kansas City, MO 64106 (816–758–5533); Boston, MA, hearing: Kathy Healy, DOE Region 1, 150 Causeway St., Boston, MA 02114 (617–223–5257); Atlanta, GA, hearing: Dan McAlister, DOE Region 4, 1655 Peachtree St., N.E., Atlanta, GA 30309 (404–881–2696); Los Angeles, CA, hearing: Terry Osborne, Department of Energy, 111 Pine St., San Francisco, CA 94111 (415–556–4953).

Any speaker who wishes to ask a question may submit the question in

writing to the presiding officer. The presiding officer will determine whether time permits the question to be asked.

Any further procedures needed for the conduct of each hearing will be announced by the presiding officer.

A transcript of each hearing will be made and will be retained by DOE. The transcript will be available for inspection between the hours of 8:00 a.m. and 4:30 p.m., Monday through Friday, except Federal holidays, at the offices listed in the beginning of the preamble. Any person wishing to do so may purchase a copy of a transcript from the reporter.

If DOE must cancel a hearing, DOE will make every effort to publish an advance notice of such cancellation in the **Federal Register**. Notice of cancellation will also be given to all persons scheduled to speak at the hearing. Hearing dates after the first scheduled day may be cancelled in the event no public testimony has been scheduled in advance.

8.0 A Guide to the Proposed Rule

8.1 Introduction

The proposed rule sets forth the requirement that the Design Energy Consumption of the design of a new building shall not exceed its Design Energy Budget. It discusses the criteria and evaluation methods to be used to determine both the Design Energy Budget and the Design Energy Consumption for a building design.

The Design Energy Budgets are expressed in thousands of Btu's per square foot of gross area per year. They vary by building design classification and climate, and they include different weighting factors for different fuels.

8.2 Application of the Proposed Standards to a Typical Building Design Process

This section describes how the proposed Standards might be applied to a typical building design process. The discussion is only for illustration purposes, since the design process varies with building type, as well as local or regional design and construction practices, and since the mechanisms for implementation are not yet available.

The first step would be to select the compliance path desired. Two general compliance paths are described in the proposed rule:

- A performance path, involving determining the Design Energy Consumption for a building design.
- An equivalent path, using an approved building code.

The performance path is the one described most fully in the proposed rule. The equivalent path assumes the existence of an approved component performance code or other procedure that DOE has determined would result in building designs whose Design Energy Consumptions would be "equivalent" to those that would result from the performance path.

If the equivalent path is taken, the building would be designed to comply with the applicable code. Ths submittal documents for building code approval would contain required documentation to substantiate compliance with the code. Such equivalent codes have not yet been identified or developed, nor have the detailed steps to be followed been developed (see Section 5.0 for implementation discussion).

8.3 The Performance Path

The basic steps in a typical performance path are described below. Applicable sections of the proposed rule and other sections of the preamble are referenced throughout the discussion.

Figure 8–1 shows the basic steps in the typical process. The numbered boxes illustrate the nature of the proposed Standards and how they would be expected to work. The numbers are for reference only and do not necessarily indicate sequence.

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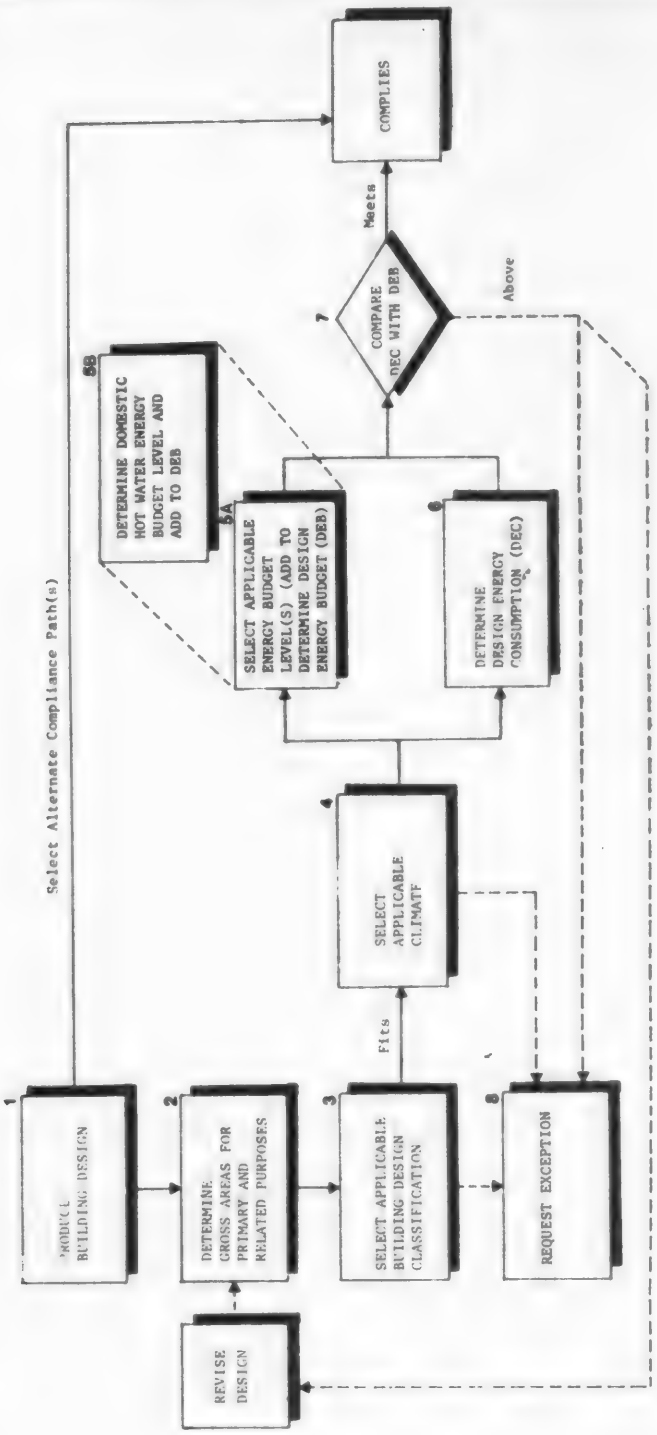

FIGURE 8-1: APPLICATION OF PROPOSED STANDARDS TO TYPICAL BUILDING DESIGN PROCESS

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• Produce building design (Box 1).

This is the set of detailed plans and specifications which describe the building, its systems and components and their interconnections.

• Determine gross area for primary and related purposes (Box 2).

Use the definition of gross area in proposed § 435.02. Then, for a commercial or multifamily residential building design, compute the total area devoted to the primary building function(s) and related purposes (see proposed § 435.04 for definitions of the "primary function(s) and related purposes"). For a single-family residential building, determine the gross area of the residence.

• Select applicable building design classification based on the gross area determination (Box 3).

Compare the total gross area computed above to the building design and function classifications in proposed § 435.04. If the percentage of total gross area for primary and related purposes is greater than or equal to that contained in one of the classifications, proceed to the selection of applicable climate conditions. If the total is less, follow the procedure for multifunctional buildings, contained in Appendix I of the proposed rule. For single-family residential buildings, simply determine the appropriate classification (attached or detached) from the definitions in proposed § 435.04. For a building design that does not fit any of the building design classifications or the definition of a multifunctional building, an exceptions procedure will be provided (Box 8).

• Select applicable climate for the selected building design classification (Box 4).

If the building site lies within one of the 78 SMSA's or cities listed in the table in Appendix II of the proposed rule, then the climate conditions for that location shall apply. If the location is not listed in that table, follow the procedures prescribed in Appendix II to choose one of the 78 SMSA's or cities whose climate conditions most closely approximate the climate conditions in the locale of the building site.

If there is no SMSA or city meeting the above criteria, and if it can be demonstrated that the building design is strongly dependent upon local climatology for successful operation, an exceptions procedure will be provided (Box 8).

• Determine applicable Design Energy Budget (Box 5A).

The tables in Appendix I of the proposed rule provide the proposed Energy Budget Levels for building design (or function) classifications. Tables I–1 and I–2 are for single-family residential building designs and Table I–3 is for commercial and multifamily residential building designs.

For single-function commercial and multifamily residential buildings, consult Table I–3 for the appropriate design classification and SMSA or city and read off the Design Energy Budget for the building design.

For multifunctional commercial and multifamily residential buildings, use Table I–3 in the same manner as above, but use the information obtained from the table as Energy Budget Levels for the functions in the building and then calculate a weighted average to determine the Design Energy Budget for the building design.

For single-family residential building designs, first consult Table I–1 to determine the space conditioning portion of the Design Energy Budget (in MBtu/sq.ft./yr.). Then, consult Table I–2 (Box 5B) to obtain the domestic hot water portion of the Design Energy Budget (in MBtu/yr./residence). Convert this number to MBtu/sq. ft./yr by dividing it by the gross area of the residence. Finally, add this to the first number to arrive at the Design Energy Budget for the building design.

The above procedure indicates that the Design Energy Budget is determined after the building design is accomplished. This is in accord with the typical building code compliance process. Also, the precise gross area of the building design is not available to determine the building design classification until the building design has been produced.

However, it seems likely that a prudent designer, builder or owner would want to know the general Design Energy Budget target from the outset of the design process. This could still be accomplished using the above procedures, but it would be based on the general area information usually available from the program of design requirements for the building (e.g., "a 1600 sq. ft. house," or "a 100,000 sq. ft. office building with 90,000 sq. ft. of office and related spaces and a 10,000 sq. ft. computer center").

The preliminary estimate of the Design Energy Budget would then be used throughout the design process as an energy target, much as a cost budget is used throughout the design process as a cost target. It would be refined for the compliance process described here, once the building design is completed.

Many key design decisions which have major impacts on energy requirements occur early in the design process (location on the site, basic shape, structure and materials, initial criteria and selection of heating, cooling, ventilating and lighting systems). A preliminary Design Energy Budget can be used as a guide for such design decisions.

• Determine Design Energy Consumption (Box 6).

Use the Standard Evaluation Technique or an approved alternate evaluation technique [61] to determine the Design Energy Consumption of the Building design.

The Evaluation technique is the key element in using the performance path to determine if a building design is in compliance with the Standards. The Standard Evaluation Technique is the one provided in the proposed rule and is the one against which other evaluation techniques will be compared to see if they can be approved as alternates.

Alternate evaluation techniques may be either computer based techniques or techniques based on hand calculation methods. In either case, appropriate criteria and procedures for their use would be included. Proposed § 435.06 contains a procedure for requesting approval of an evaluation technique as an alternate for use with the Standards.

Use of the Standard Evaluation Technique requires that certain specific data be used: The climate data selected in Box 4; building design data; Standard Building Operating Conditions, which are provided by DOE for each building design classification and are included in Technical Support Document No. 1, The Standard Evaluation Technique; and weighting factors expressed by fuel type.

The weighting factors were developed by DOE (see Section 2.4.1) and used as a way of expressing the proposed Energy Budget Levels. They must therefore be used in arriving at the Design Energy Consumption of a building design. This is done by: (1) Determining the design energy requirements of the building design (in MBtu/sq. ft./yr), by fuel type; (2) multiplying each of the fuel-related design energy requirements by the applicable weighting factor; and then (3) adding all of the weighted figures to arrive at the Design Energy Consumption for the building design. The design energy requirements of the building design are determined using the calculation methods and associated instructions in the Standard Evaluation Technique.

The use of a renewable energy resource will result in a "credit" toward meeting the design goal, as that energy

[61] See Section 4.0 of the preamble for a brief description of the Standard Evaluation Technique, and Technical Support Document No. 1, The Standard Evaluation Technique, for a complete description and a full discussion of related issues.

is not counted in determining the Design Energy Consumption.

• Compare Design Energy Consumption with Design Energy Budget (Box 7)

If the Design Energy Consumption calculated in the previous step does not exceed the Design Energy Budget, then the building design is in compliance with the Standards, the process is complete, and the appropriate documentation for building code approval can be submitted.

Where a building's Design Energy Consumption exceeds its Design Energy Budget, the building design would have to be modified in order for it to be in compliance with the Standards.

For those building designs which have special health and fire safety requirements or considerations, or which have systems or components that cannot be evaluated in a reasonable manner by the Standard Evaluation Technique, exceptions procedures will be provided (Box 8).[62]

8.4 Designing Buildings for Compliance With the Proposed Standards

This section describes how building designs might change from current practice in complying with the proposed Standards.

Buildings use energy for building functions and human occupancy. Such uses include lighting, domestic hot water, and vertical transportation. In addition, when the building design is not able to temper climate extremes, energy is used for heating, cooling, and ventilating systems to maintain comfort and health conditions. Therefore, the first objective would be to design the building to minimize the demand for the use of such systems. A second objective would be to use the most energy efficient and cost-effective systems appropriate for the building and the climate.

The proposed Standards would accelerate existing trends toward:

• Less demand for energy using systems.

• Buildings which are more sensitive to climate and site energy conservation opportunities, and are designed to minimize negative site and climate factors. (Buildings will work more in harmony with the surrounding climate and site, to make use of heat gain, heat loss, available light, and outside air in the comfort range. This might include such techniques as passive solar design strategies, cost-effective levels of insulation, and double or triple glazing.)

• More efficient heating, cooling, ventilating and lighting systems.

• More sophisticated controls, both manual and computerized, for more efficient building systems operation.

• Greater use of active solar and other advanced domestic hot water systems, especially in residential buildings.

A performance standard provides significant flexibility and opportunity for tradeoffs among the subsystems and components of a building design in order to meet an overall energy goal. An owner's requirements for a building design could be achieved with a number of different design possibilities. Consider as an example three new single-family residences that might be designed for the same block in the suburb of a midwest city. The houses could all be designed to comply with the proposed Standards; however, they could all be different:

• The first house could rely on traditional energy conservation strategies and emphasize insulation, triple glazing, and efficient heating and cooling systems. Windows would be placed equally on all four sides of the house.

• The second house could include passive solar heating and cooling techniques (primarily, the relocation of windows to the south wall, along with appropriately located building mass and shading devices), in addition to traditional energy conservation measures such as added insulation and double glazing.

• The third house could emphasize the addition of an active solar domestic hot water system, plus some traditional conservation measures, such as added insulation and double glazing.

All three houses could be generally similar in style, they could all meet the same budget, but they would each use a different approach.[63] The design of commercial and multifamily residential buildings also generally involves many options for design solutions which meet the requirements of the Standards.[64] Thus, the standards would allow energy objectives and design flexibility to be combined.

(Energy Conservation Standards for New Buildings Act of 1976, as amended, (42 U.S.C. 6831–6840), enacted as Title III of the Energy Conservation and Production Act; and Department of Energy Organization Act, (42 U.S.C. 7101 *et seq.*))

In consideration of the foregoing, Chapter II of Title 10, Code of Federal Regulations, is amended by establishing Part 435 as set forth below.

[62] For a summary list of anticipated exceptions leading to administrative review procedures, see Section 1.4.7 of the preamble.

[63] For further discussion of some possible design alternatives for single-family residences, see Section 3.3.7 of the preamble and Table 3–1.

[64] See footnote 35.

Issued in Washington, D.C., this 14th day of November 1979

Maxine Savitz,

Acting Assistant Secretary, Conservation and Solar Energy.

Chapter II of Title 10, Code of Federal Regulations, is amended by establishing a new Part 435 as follows:

PART 435—ENERGY PERFORMANCE STANDARDS FOR NEW BUILDINGS

Subpart A—Performance Standards

Sec.

435.01 Purpose and scope.
435.02 Definitions.
435.03 Requirements for the performance standards.
435.04 Building design and function classification.
435.05 Selection of applicable climate.
435.06 Procedure for establishing alternate evaluation techniques.

Subpart B—Implementation [Reserved]

Subpart C—Administrative Review [Reserved]

Appendix I: Energy Budget Level Tables.
Appendix II: Climate Tables.
Appendix III: Approved Alternate Evaluation Techniques [Reserved].
Appendix IV: Model Codes and Standards [Reserved].

Authority: Energy Conservation Standards for New Buildings Act of 1976, as amended, (42 U.S.C. 6831–6840), enacted as Title III of the Energy Conservation and Production Act; Department of Energy Organization Act (42 U.S.C. 7101 *et seq*).

Subpart A—Performance Standards

§ 435.01 Purpose and scope.

This part establishes energy performance standards for new residential and commercial buildings. It also establishes the requirements for implementation of the standards. The purpose of the energy performance standards is to achieve the maximum practicable improvements in energy efficiency in new buildings. The standards will be implemented to:

(a) Redirect Federal policies and practices to assure that reasonable energy conservation features will be incorporated into the designs of new commercial and residential buildings receiving Federal financial assistance;

(b) Achieve in the designs of new commercial and residential buildings the maximum practicable improvements in energy efficiency and increases in the use of nondepletable sources of energy; and

(c) Encourage States and local governments to adopt and enforce such standards through their existing building codes and other construction control mechanisms, or to apply them through a special approval process.

§ 435.02 Definitions.

For purposes of this part: (a) "British thermal unit" means the amount of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit at an atomospheric pressure of 14.73 pounds per square inch absolute.

(b) "Btu" means British thermal unit.

(c) "Building code" means a legal instrument which is in effect in a State or unit of general purpose local government, the provisions of which must be adhered to if a building is to be considered in conformance with the law and suitable for occupancy and use.

(d) "Building design" means the architectural and engineering drawings and specifications used for the construction of a new building.

(e) "Commercial building" means a new building other than a residential building, including any building developed for industrial or public purposes.

(f) "Design Energy Budget" means the maximum allowable Design Energy Consumption, expressed as MBtu/sq. ft./yr, for a building design for a new building, without specification of the methods, materials or processes to be employed in the design.

(g) "Design Energy Consumption" means the calculated annual energy consumption, expressed as MBtu/sq. ft./yr, for the gross area of a building design, calculated using the Standard Evaluation Technique specified by DOE, or an approved alternate evaluation technique.

(h) "DOE" means the U.S. Department of Energy.

(i) "Energy Budget Level" means a value, expressed in MBtu/sq. ft./yr, for a building classification for a specific climate and location developed in the tables contained in Appendix I.

(j) "Federal agency" means any department, agency, corporation, or other entity or instrumentality of the Executive Branch of the Federal Government, including the United States Postal Service, the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation.

(k) "Federal building" means any building to be constructed by, or for the use of, any Federal agency which is not legally subject to State or local building codes or similar requirements.

(l) "Function" means a designated type of activity for an area identified as part of a building design.

(m) "Gross area" means the sum of all floor areas, except unheated basements in single-family residences or parking areas, measured in square feet, enclosed in a building design, measured from the exterior face of exterior walls at the floor line, disregarding protrusions beyond the nominal plane of the wall, or from the centerline of common walls separating buildings.

(n) "MBtu" means thousands of British thermal units.

(o) "MBtu/sq. ft./yr" means MBtu per square foot of gross area per year.

(p) "New building" means any structure (1) which includes or will include a heating or cooling system, as defined in 10 CFR 450.41, or both, or a domestic hot water heating system, and (2) for which the construction commences after the final rule becomes effective, with the exception that mobile homes, industrial buildings and restaurants are excluded from this definition.

(q) "Residential building" means a new building which is designed to be constructed and developed for residential occupancy.

(r) "Standard Metropolitan Statistical Area" means an area defined by the Department of Commerce in its publication, "SMSA, 1975," Division of Standards and Policy, ed. 1975, with revisions.

(s) "Standard Evaluation Technique" means the criteria, procedures and energy calculation methods used for determining the Design Energy Consumption of a new building design, and consists of Appendix V of the DOE Technical Support Document, "The Standard Evaluation Technique," Administrative Record Number 9561.00 (November 1979), and the energy analysis programs shown in Table 1.

§ 435.03 Requirements for the performance standards.

(a) The Design Energy Consumption of the building design of a new building shall not exceed its Design Energy Budget.

(b) The Design Energy Budget shall be determined by: (1) Classifying the building design in accordance with § 435.04;

TABLE 1.—SOURCES OF THE STANDARD EVALUATION TECHNIQUE COMPUTER PROGRAMS

I. DOE–2.0 available from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22150.

Item and Order No.

1. DOE–2 Magnetic Tapes, Program, Sample Runs, Weather Data (Sold only as a set)—P–B–292250
2. DOE–2 Manual Set

Volume 1: Users Guide—P–B–292251
Building Design Language Summary—P–B–292251–1

Sample Run Book

Volume 2: Reference Manual—P–B–292251–2
Volume 3: Program Manual (Sold only as a set)—P–B–292251–3

II. TRNSYS–10.1 available from: TRNSYS Coordinator, University of Wisconsin-Madison, Solar Energy Laboratory, 1500 Johnson Drive, Madison, WI 53706, Phone: 606–263–1586.

1. User's Manual Standards Addendum to User's Manual TRNSYS on Magnetic Tape
2. User's Manual Standards Addendum to User's Manual TRNSYS on Card Deck

III. DEROB–3.0 available from: Solar Energy Research Institute, ATTN: Mr. M. Connelly, 1536 Cole Boulevard, Golden, CO 80401.

1. Volume 1. User's Manual
2. Volume 2. Explanatory Notes of Theory
3. Standards Addendum
4. DEROB–3.0 Magnetic Tape

(2) Selecting the appropriate climate data for the location of the new building in accordance with §435.05; and

(3) Determining the MBtu/sq. ft./yr permitted for the building design from the Energy Budget Level tables and instructions contained in Appendix I.

(c) The Design Energy Consumption shall be calculated in accordance with: (1) The Standard Evaluation Technique, or (2) an approved alternate evaluation technique as provided in Appendix III.

(d) For purposes of this subpart, a building design which meets the requirements of a model code or standard listed in Appendix IV shall be deemed to have a Design Energy Consumption which does not exceed its Design Energy Budget.

§ 435.04 Building design and function classifications.

(a) A building design shall be classified as one of the following:

(1) "Clinic," a building design in which at least 90 percent of the gross area is primarily for use in outpatient medical, surgical or psychiatric diagnosis and treatment and related purposes, without provisions for overnight accommodations and associated care. Related purposes in this classification include office spaces, storage areas, public waiting rooms, toilet rooms, corridors, stairwells, laboratory spaces, equipment spaces, shafts and lobbies.

(2) "Community center," a building design in which at least 98 percent of the gross area is primarily for use in public non-athletic recreational activities, meetings, lectures, conferences, exhibitions, games, and related purposes. Related purposes in this classification include office spaces, storage areas, public waiting rooms, toilet rooms, corridors, stairwells, equipment spaces, shafts and lobbies.

(3) "Gymnasium," a building design in which at least 97 percent of the gross area is primarily for use in physical education activities, recreational athletic activities and athletic entertainment events and related

purposes. Related purposes in this classification include indoor tennis courts, handball courts, racquetball courts, running tracks, squash courts, shower and locker areas, offices, public waiting rooms, corridors, stairwells, toilet areas, storage rooms and spaces, equipment spaces, shafts, lobbies and seating areas.

(4) "Hospital," a building design in which at least 80 percent of the gross area is primarily for use in rendering outpatient and inpatient medical, surgical or psychiatric diagnosis and treatment and related purposes, with provisions for overnight accommodations and associated care. Related purposes in this classification include office spaces, classrooms, public waiting rooms, toilet rooms, corridors, stairwells, storage areas, kitchens and food services spaces, meeting and consultation rooms, equipment areas, laundry areas, supply areas, laboratory spaces, lobbies and shafts.

(5) "Hotel/motel," a building design in which at least 80 percent of the gross area is primarily for rental, on a transient basis, of separate rooms or sets of rooms as sleeping accommodations, and related purposes. Related purposes in this classification include office spaces, meeting rooms and conference rooms, storage rooms and spaces, public waiting rooms, corridors, stairwells, lobbies, equipment areas and shafts.

(6) "Industrial building," a building design in which at least 50 percent of the gross area is primarily for carrying out one of the industrial activities referred to in the 20 two-digit categories listed in the Standard Industrial Classification System as contained in the Standard Industrial Classification Manual, United States Executive Office of the President, Office of Management and Budget, 1972.

(7) "Mobile home," a structure transportable in one or more sections, which measures at least eight body feet in width and 32 body feet in length, erected on a permanent chassis with or without a permanent foundation and designed to be used as a dwelling unit when connected to the required utilities and includes plumbing, heating, air-conditioning and electrical systems contained therein. This classification does not include structures which are self-movable.

(8) "Nursing home," a building design in which at least 83 percent of the gross area is primarily for the lodging, boarding and medical or health care, on a 24-hour basis, of persons who, because of physical or mental incapacity, may be unable to provide for their own safety or personal needs, and related purposes. Related purposes in this classification include office areas, meeting rooms, consultation rooms, storage areas, stairwells, shafts, lobbies, corridors, public toilet rooms, equipment rooms and supply areas.

(9) "Office, large," a building design for other than a store or shopping center with a gross area of 50,000 square feet or more, in which at least 86 percent of the gross area is primarily for the transaction of business or the rendering of professional services, and related purposes. Related purposes in this classification include storage areas, public toilet rooms, stairwells, lobbies, shafts, supply areas, equipment rooms, meeting and consultation rooms.

(10) "Office, small," a building design for other than a store or shopping center with a gross area of less than 50,000 square feet, for which at least 87 percent of the gross area is primarily for the transaction of business or the rendering of professional services, and related purposes. Related purposes in this classification include storage areas, public toilet rooms, stairwells, lobbies, shafts, supply areas, equipment rooms, meeting and consultation rooms.

(11) "Restaurant," a building design in which 93 percent of the gross area is primarily for the preparation, sale and consumption, on or off the premises, of food and drink, and related purposes. Related purposes in this classification include equipment areas, offices, lobbies, waiting rooms, refrigeration areas, stairwells, shafts, supply areas, kitchens and heating areas.

(12) "Residential, multifamily high-rise," a residential building design, five or more stories in height which is not single-family attached as defined in paragraph (a)(14) of this section and in which at least 90 percent of the gross area is primarily to provide complete and independent living units, and related purposes. Related purposes in this classification include stairwells, shafts, public toilet rooms, lobbies, corridors, equipment areas, storage areas and laundry rooms.

(13) "Residential, multifamily low-rise," a residential buiding design, four or fewer stories in height, which is not single-family attached as defined in paragraph (a)(14) of this section and in which at least 92 percent of the gross area is primarily to provide complete and independent living units, and related purposes. Related purposes in this classification include stairwells, shafts, public toilet rooms, lobbies, corridors, equipment areas, storage areas and laundry rooms.

(14) "Residential, single-family attached," a building design that provides a complete and independent living unit for a single family and in which the unit is structurally connected, without a hallway or corridor, in the horizontal dimension only to not less than one other unit.

(15) "Residential, single-family detached," a building design that provides a complete and independent living facility for a single family and is not structurally connected in any dimension to any other unit.

(16) "School, elementary," a building design in which at least 84 percent of the gross area is primarily for academic or vocational instruction, learning or care for up to and including the eighth grade, and related purposes. Related purposes in this classification include offices, libraries, classrooms, storage areas, toilet rooms, waiting rooms, auditoriums, gymnasiums, equipment areas, stairwells, lobbies, shafts and supply areas.

(17) "School, secondary," a building design in which at least 84 percent of the gross area is primarily for academic or vocational instruction, learning or care for any grade above the eighth grade, and related purposes. If a school building includes grades above and below the eighth grade, it will be considered a secondary school. Related purposes in this classification include offices, libraries, classrooms, storage areas, toilet rooms, waiting rooms, auditoriums, gymnasiums, equipment rooms, stairwells, lobbies, shafts and supply areas.

(18) "Shopping center," a building design, other than a store or office, serving more than one tenant, in which at least 78 percent of the gross area is designed for the display and sale of merchandise, the transaction of business or the rendering of professional services, and related purposes. Related purposes in this classification include common public circulation areas that may or may not be covered, stock and storage areas, public toilet rooms, stairwells, lobbies, shafts, supply areas, equipment rooms, meeting and consultation rooms.

(19) "Store," a building design in which at least 98 percent of the gross area is designed primarily for the display and sale of merchandise, the transaction of business or the rendering of professional services, and related purposes, but not including a common public circulation area. Related purposes in this classification include stock and storage rooms, stairwells, lobbies, shafts, supply areas, public toilet rooms, equipment rooms, meeting and consultation rooms.

(20) "Theater/auditorium," a building design in which at least 87 percent of the gross area is designed primarily for the showing of plays, operas, motion pictures, concerts and other similar

forms of entertainment, and related purposes. Related purposes in this classification include storage areas, public toilet rooms, stairwells, lobbies, shafts, supply areas, equipment rooms, meeting and consultation rooms.

(21) "Warehouse," a building design in which at least 97 percent of the gross area is designed primarily for the climate controlled storage or sheltering of goods, merchandise, products, foodstuffs or vehicles, and related purposes. Related purposes in this classification include office areas, toilet rooms, equipment areas, lobbies, waiting rooms, stairwells and shafts.

(22) If the building design of a new building does not meet the terms of a definition contained in paragraphs (a)(1) through (21) of this section, it shall be classified as "OTHER."

(b) For a building design for a multifunctional new building, the functions shall be classified in accordance with § 435.04(a).

§ 435.05 Selection of applicable climate.

(a) If the new building is to be located within an SMSA or city listed in Appendix I, the climate data of that SMSA or city shall be selected

(b) If the new building is not to be located within an SMSA or city listed in Appendix I, the climate data which most closely approximates the climate of the SMSA or city in which the new building will be located shall be selected. This selection shall be made in accordance with the instructions and tables given in Appendix II, Climate Tables.

§ 435.06 Procedure for establishing alternate evaluation techniques.

(a) A person may submit a written application to DOE on an application form to be provided by DOE, requesting approval of a procedure as an alternate evaluation technique.

(b) After DOE receives an application and any additional information requested, DOE shall determine whether the procedure submitted is acceptable as an alternate evaluation technique.

(c) If DOE determines that the procedure is likely to produce results equivalent to the Standard Evaluation Technique, DOE shall approve the procedure, with such limitations or qualifications as DOE shall find appropriate, and shall give public notice of its inclusion in Appendix III by publication in the **Federal Register**.

Subpart B—Implementation [Reserved]

Subpart C—Administrative Review [Reserved]

Appendix I: Energy Budget Level Tables.

1. *General.* To use these tables, the user must determine the appropriate building design classification under § 435.04. If the building design is classified as residential, single-family attached or detached, under § 435.04(a)(14) or (15), the Residential Energy Budget Level tables (Tables I–1 and I–2) shall be used. For any other classification, the commercial and multifamily residential Energy Budget Level table (Table I–3) shall be used. In using either set of tables, the user must also select the appropriate climate conditions under § 435.05.

2. *Use of the single-family residential Energy Budget Level tables.* If the building design is classified under the provisions of § 435.04(a)(14) or (15), add two Energy Budget Levels to determine the Design Energy Budget: (1) The Energy Budget Level for heating and cooling the structure, and (2) the Energy Budget Level for heating domestic hot water. The following steps shall be used:

(1) From Table I–1, select the appropriate space heating Energy Budget Level for the building type for the SMSA or city selected under § 435.05 and the fuel type determined in 1 above. If a renewable resource is used exclusively (i.e., there is no nonrenewable energy supplemental system), select any fuel type.

(2) Use the climate conditions determined under § 435.05 and the fuel type selected in (1) to select the appropriate Energy Budget Level for heating and cooling from Table I–1.

(3) Calculate the gross area of the building design.

(4) Identify whether gas, oil, or electricity is the fuel that will be used to provide the energy for heating domestic hot water. If a renewable resource is used exclusively (i.e., there is no nonrenewable energy supplemental system), select one of the aforementioned fuel types.

(5) From Table I–2, select the approrpriate domestic hot water factor for the fuel type selected in (4).

(6) Divide the domestic hot water factor from (5) by the gross area of the building design from (3).

(7) Add the results of (2) and (6). This sum is the Design Energy Budget.

3. *Use of commercial and multifamily residential Energy Budget Level tables*—(a) *Single-function buildings.* If the building design for a new building is classified under the provision of § 435.04(a)(1) through (21) other than (14) and (15), use the Energy Budget Level provided in Table I–3.

(b) *Multifunction buildings.* If the building design is classified "OTHER" under § 435.04(a)(22), calculate the Design Energy Budget for that building design in the following manner:

(1) Calculate the gross area of the building design.

(2) Identify the building function classifications contained in § 435.04(a).

(3) Determine the square feet of gross area for each of the function classifications identified in (2), including related purposes such as lounges, hallways, entrances and lobbies associated with the function. Include as part of another function the area of any function for which the square feet of gross area is less than 15 percent of the gross area but not in excess of 1,000 square feet.

(4) For each of the function classifications determined in (2), select from Table I–3 the Energy Budget Level appropriate for the location of the new building.

(5) Sum the square feet of gross area for each function for which there is an Energy Budget Level in Table I–3. If this sum is less than 50 percent of the gross area, the building design has no Design Energy Budget and is excepted.

(6) For each function for which there is an Energy Budget Level, multiply the level selected in (4) by the square feet of gross area for that function, from (3).

(7) Sum the products calculated in (6) and divide the resultant sum by the resultant area calculated in (5).

(8) The result of (7) is the Design Energy Budget for a multifunctional building design.

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Table I-1: HEATING AND COOLING ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ sq. ft./ yr)

State	SMSA	Single-Family Detached			Single-Family Attached		
		Gas	Oil	Electric	Gas	Oil	Electric
Alabama	Birmingham	27.1	29.8	26.7	20.6	22.5	30.4
	Mobile	26.0	26.7	26.7	21.5	22.1	20.5
Arizona	Phoenix	29.2	30.2	30.1	24.0	24.8	23.3
California	Bakersfield	25.0	26.8	24.6	19.6	20.9	18.5
	Fresno	24.4	26.7	23.6	18.6	20.2	17.5
	Los Angeles	14.1	14.8	12.7	11.4	11.9	9.2
	Oakland	13.8	16.0	10.9	9.6	11.1	7.3
	Sacramento	22.3	25.0	21.0	16.6	18.4	15.4
	San Diego	15.2	15.5	14.4	12.7	13.0	10.7
	San Francisco	14.2	16.7	11.3	9.7	11.4	7.6
Colorado	Denver	33.7	40.3	38.4	24.6	29.5	29.2
Connecticut	Bridgeport	33.3	39.3	36.8	24.4	28.8	27.9
	Hartford	37.1	44.2	43.5	27.4	32.8	33.5
D. C.	Washington	31.2	35.7	32.4	23.1	26.3	24.3
Florida	Jacksonville	26.9	27.6	27.9	22.3	22.9	21.4
	Miami	34.3	34.4	37.1	29.0	29.1	29.1

Note: [illegible] assumed to be provided by electricity in all cases

Table I-1: HEATING AND COOLING ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ sq. ft./ yr) (CONT'D)

State	SMSA	Single-Family Detached			Single-Family Attached		
		Gas	Oil	Electric	Gas	Oil	Electric
Florida	Tampa	28.6	28.7	30.9	24.5	24.7	24.0
Georgia	Atlanta	26.3	29.1	25.7	19.8	21.8	19.2
Idaho	Boise City	35.1	41.7	40.0	25.8	30.7	30.6
Illinois	Chicago	39.1	46.5	46.6	29.2	34.8	36.0
	Glenview	40.0	47.4	47.6	30.0	35.6	36.8
Indiana	Indianapolis	39.0	46.1	45.6	29.2	34.4	35.1
Kansas	Dodge City	28.3	32.9	32.8	37.9	44.1	42.8
Kentucky	Louisville	32.9	38.1	35.2	24.3	28.0	26.6
Louisiana	Baton Rouge	26.3	27.1	27.0	21.7	22.3	20.7
	Lake Charles	28.0	29.3	28.5	22.6	23.6	21.7
	New Orleans	27.9	29.3	28.3	22.4	23.5	21.5
Maine	Portland	44.6	54.3	46.8	34.6	42.2	46.6
Massachusetts	Boston	36.3	43.2	42.1	26.9	32.0	32.2
Michigan	Detroit	40.8	48.7	49.8	30.7	36.7	38.6
Minnesota	Minneapolis	56.9	68.3	80.2	45.4	54.6	64.0
Mississippi	Jackson	28.8	31.0	28.9	22.5	24.1	21.8
Missouri	Columbia	36.8	42.8	41.0	27.4	31.8	31.3
	Kansas City	37.5	43.3	41.5	28.0	32.3	31.7

Note: Cooling is assumed to be provided by electricity in all cases.

Table I-1: HEATING AND COOLING ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ sq. ft./ yr) (CONT'D)

State	SMSA	Single-Family Detached			Single-Family Attached		
		Gas	Oil	Electric	Gas	Oil	Electric
Missouri	St Louis	38.0	44.2	42.7	28.4	32.9	32.7
Montana	Great Falls	45.1	54.7	59.6	34.6	42.1	46.9
Nebraska	Omaha	41.6	49.2	50.0	31.4	37.1	38.7
Nevada	Las Vegas	30.7	32.8	31.3	24.3	25.8	23.8
New Jersey	Newark	33.7	39.2	36.5	24.9	28.8	27.7
New Mexico	Albuquerque	31.6	63.4	33.1	23.3	36.4	24.9
New York	Albany	44.9	54.1	58.2	34.3	41.5	45.6
	Binghamton	48.2	58.3	65.2	37.4	45.4	51.5
	Buffalo	41.3	49.8	51.9	31.1	37.7	40.4
	New York	31.0	36.0	32.7	22.7	26.3	24.6
No. Carolina	Raleigh	28.5	32.3	28.7	21.2	23.8	21.4
North Dakota	Bismarck	63.0	76.4	95.6	51.8	62.9	77.2
Ohio	Akron	39.6	47.4	48.0	29.7	35.5	37.1
	Cincinnati	34.8	40.6	38.2	25.8	29.9	29.0
	Cleveland	41.3	49.4	50.9	31.1	37.3	39.5
	Columbus	39.8	47.2	47.4	29.8	35.4	36.6

Note: Cooling is assumed to be provided by electricity in all cases.

Table I-1: HEATING AND COOLING ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ sq. ft./ yr) (CONT'D)

State	SMSA	Single-Family Detached			Single-Family Attached		
		Gas	Oil	Electric	Gas	Oil	Electric
Oklahoma	Oklahoma City	33.0	37.2	34.3	24.7	37.0	25.9
	Tulsa	31.2	35.0	31.9	23.4	26.1	24.0
Oregon	Medford	25.8	30.5	26.0	18.3	21.7	19.2
	Portland	25.3	30.5	26.0	17.8	21.4	19.2
Pennsylvania	Allentown	35.0	41.5	39.8	25.8	30.6	30.3
	Philadelphia	35.7	41.8	39.8	26.5	30.9	30.3
	Pittsburgh	36.7	43.6	42.4	27.2	32.3	32.5
So. Carolina	Charleston	26.3	28.3	26.1	20.6	22.0	19.6
Tennessee	Memphis	29.7	32.9	29.9	22.5	24.8	22.4
	Nashville	29.1	32.8	29.3	21.7	24.3	21.9
Texas	Amarillo	30.7	35.3	31.8	22.7	25.9	23.9
	Brownsville	31.6	31.8	34.5	27.1	27.3	26.9
	Dallas	31.7	33.9	32.5	25.1	26.6	24.7
	El Paso	27.8	30.3	27.6	21.3	23.1	20.7
	Fort Worth	29.0	31.1	29.2	22.8	24.2	22.1
	Houston	28.5	29.7	29.2	23.1	24.0	22.3
	Lubbock	29.4	33.1	22.2	22.0	24.6	22.9

Note: Cooling is assumed to be provided by electricity in all cases.

Table I-1: HEATING AND COOLING ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ sq. ft./ yr) (CONT'D)

State	SMSA	Single-Family Detached			Single-Family Attached		
		Gas	Oil	Electric	Gas	Oil	Electric
Texas	San Antonio	29.5	31.1	30.1	23.6	24.8	22.9
Utah	Salt Lake City	40.6	48.2	48.7	30.5	36.2	37.6
Vermont	Burlington	49.1	59.6	67.5	38.3	46.7	53.5
Virginia	Norfolk	27.0	30.3	26.7	20.1	22.4	19.8
	Richmond	33.1	38.2	35.3	24.5	28.1	26.7
Washington	Seattle	25.6	31.3	26.5	18.6	22.7	19.6
	Spokane	38.3	46.5	47.6	28.5	34.8	36.9
West Virginia	Charleston	33.1	38.5	35.7	24.3	28.3	27.0
Wisconsin	Madison	45.4	54.8	59.6	34.8	42.2	46.8
	Milwaukee	45.3	54.8	59.4	34.8	42.1	46.7
Wyoming	Cheyenne	41.1	49.9	52.5	31.0	37.8	41.0

Note: Cooling is assumed to be provided by electricity in all cases

Table I-2: DOMESTIC HOT WATER ENERGY BUDGET LEVELS FOR SINGLE-FAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/ yr./ unit)

Gas	Oil	Electric
29,500	42,500	54,600

Note: Divide by gross area of the new building and add the result to appropriate heating and cooling Energy Budget Level from Table I-1.

Table I-3: ENERGY BUDGET LEVELS FOR COMMERCIAL AND MULTIFAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/sq. ft./yr)

State	SMSA	[illegible]	Commercial Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High Rise	Multifamily Low Rise	Nursing Home	Office Large	Office Small	School Elementary	School Secondary	Shopping Center	Store	Theater Auditorium	Warehouse
Alabama	Birmingham	123	107	127	353	166	114	110	161	113	101	89	117	181	142	139	53
	Mobile	142	129	147	406	192	127	132	187	131	116	96	133	207	166	162	47
Arizona	Phoenix	146	133	152	406	196	131	136	192	134	119	100	137	212	171	168	49
California	Bakersfield	123	109	127	358	167	113	112	162	113	100	86	116	181	143	140	48
	Fresno	120	105	123	353	163	112	198	158	111	98	85	114	178	139	136	50
	Los Angeles	112	101	115	364	157	103	103	151	106	91	74	106	171	132	126	42
	Oakland	108	93	108	353	150	102	94	143	101	87	75	103	164	125	119	50
	Sacramento	118	102	120	353	160	110	104	154	108	96	84	112	175	136	132	52
	San Diego	114	103	117	364	158	104	106	153	107	92	75	107	172	134	128	40
	San Francisco	108	92	109	353	150	103	94	143	101	87	76	103	165	125	119	51
Colorado	Denver	122	98	123	338	162	119	100	156	109	100	97	118	178	137	135	71
Connecticut	Bridgeport	128	105	130	353	170	123	106	156	115	105	100	123	186	144	142	71
	Hartford	125	101	127	338	165	122	102	159	112	103	100	121	181	140	139	74
D. C.	Washington	127	107	129	353	169	120	109	164	115	104	96	121	185	144	142	63
Florida	Jacksonville	143	130	149	406	193	128	134	189	132	117	97	134	209	167	164	47
	Miami	152	142	161	406	203	133	147	201	140	125	103	141	219	179	178	41

Note: [illegible] domestic hot water fans exhaust fans [illegible]

Note: Space is reserved in this table for restaurants and industrial buildings.

Table I-3: ENERGY BUDGET LEVELS FOR COMMERCIAL AND MULTIFAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/sq. ft./yr) (CONT'D)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High Rise	Multifamily Low Rise	Nursing Home	Office Large	Office Small	School Elementary	School Secondary	Shopping Center	Store	Theater/Auditorium	Warehouse
Florida	Tampa	145	135	152	406	196	129	139	193	135	119	98	136	212	171	168	43
Georgia	Atlanta	122	106	125	353	165	114	108	160	112	100	88	116	180	141	138	53
Idaho	Boise City	124	100	125	338	163	120	101	158	111	101	98	120	179	139	137	71
Illinois	Chicago	127	102	129	338	167	124	103	161	113	104	103	123	183	142	141	75
	Glenview	129	103	130	338	168	125	105	163	114	105	103	124	184	143	143	75
Indiana	Indianapolis	128	103	130	338	168	124	105	162	114	105	102	123	184	143	142	73
Kansas	Dodge City	133	109	135	353	175	128	111	162	119	109	105	128	191	150	149	72
Kentucky	Louisville	128	107	131	353	170	122	109	165	116	105	98	123	186	145	143	66
Louisiana	Baton Rouge	142	129	147	406	192	123	132	188	131	116	97	133	208	166	163	48
	Lake Charles	144	130	149	406	194	130	133	189	133	118	100	135	210	168	165	51
	New Orleans	144	129	149	406	194	130	133	189	132	118	100	135	210	168	164	52
Maine	Portland	130	100	131	335	169	129	101	162	114	107	109	127	186	143	143	86
Massachusetts	Boston	125	101	126	338	165	121	102	159	111	102	99	121	181	140	139	72
Michigan	Detroit	129	103	130	338	168	126	104	163	114	106	105	125	185	143	143	77
Minnesota	Minneapolis	142	109	144	335	180	140	110	175	123	117	122	158	198	155	157	93
Mississippi	Jackson	127	113	131	358	171	117	115	167	117	104	90	120	186	147	145	50
Missouri	Columbia	132	109	134	353	174	126	111	161	118	108	103	127	190	149	148	71
	Kansas City	133	110	136	353	175	127	112	162	119	109	104	128	191	150	149	70

Note: Figures include design energy requirements for heating, cooling, domestic hot water, fans, exhaust fans heating and cooling auxiliaries, elevators, escalators and lighting.

Note: Space is reserved in this table for restaurants and industrial buildings.

Table I-3: ENERGY BUDGET LEVELS FOR COMMERCIAL AND MULTIFAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/sq. ft./yr) (CONT'D)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High Rise	Multifamily Low Rise	Nursing Home	Office Large	Office Small	School Elementary	School Secondary	Shopping Center	Store	Theater/Auditorium	Warehouse
Missouri	St. Louis	133	110	136	353	175	128	112	163	119	109	105	128	192	150	149	72
Montana	Great Falls	131	102	132	335	170	129	102	163	115	107	110	127	186	144	144	85
Nebraska	Omaha	130	105	132	338	170	126	106	164	115	107	105	126	186	145	145	76
Nevada	Las Vegas	130	115	135	358	174	118	113	170	119	106	92	122	188	150	148	49
New Jersey	Newark	129	107	131	353	171	123	108	165	116	105	99	124	187	146	144	68
New Mexico	Albuquerque	127	107	129	353	169	121	108	164	115	104	96	122	185	144	142	64
New York	Albany	131	102	132	335	170	129	103	164	115	108	109	127	187	145	145	83
	Binghamton	133	103	135	335	172	132	104	166	117	110	113	130	189	147	147	88
	Buffalo	129	101	130	338	168	127	102	162	114	106	106	125	185	143	142	80
	New York	126	105	128	353	168	120	107	162	114	103	96	121	184	143	141	66
No. Carolina	Raleigh	124	106	127	353	167	117	108	161	113	101	92	119	182	142	139	59
North Dakota	Bismarck	146	110	147	335	184	146	111	179	125	121	129	143	203	158	161	102
Ohio	Akron	128	102	129	338	167	125	103	161	113	105	104	124	183	142	141	77
	Cincinnati	130	107	132	353	172	124	109	166	117	106	101	125	188	147	145	70
	Cleveland	129	103	131	338	169	126	104	163	114	106	105	125	185	144	143	78
	Columbus	128	103	130	338	168	125	104	162	114	105	103	124	184	143	142	75

Note: Figures include design energy requirements for heating, cooling, domestic hot water, fans, exhaust fans, heating and cooling auxiliaries, elevators, escalators and lighting.

Note: Space is reserved in this table for restaurants and industrial buildings.

Table I-3: ENERGY BUDGET LEVELS FOR COMMERCIAL AND MULTIFAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/sq. ft./yr) (CONT'D)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/ Motel	Multifamily High Rise	Multifamily Low Rise	Nursing Home	Office Large	Office Small	School Elementary	School Secondary	Shopping Center	Store	Theater/ Auditorium	Warehouse
Oklahoma	Oklahoma City	129	110	132	353	172	121	112	167	117	106	97	123	187	147	146	61
	Tulsa	127	109	130	353	170	119	111	165	116	104	95	121	185	146	144	59
Oregon	Medford	120	99	121	353	162	116	101	155	109	98	91	116	177	136	133	64
	Portland	119	98	120	353	161	116	99	154	108	97	91	115	176	135	131	66
Pennsylvania	Allentown	129	105	131	353	171	125	106	158	116	106	102	125	187	145	144	74
	Philadelphia	131	107	133	353	173	126	109	160	117	107	102	126	189	147	146	71
	Pittsburgh	126	101	127	338	165	122	103	159	112	103	100	121	181	141	139	72
So. Carolina	Charleston	124	110	128	358	168	114	113	163	114	102	88	118	183	144	141	49
Tennessee	Memphis	126	109	129	353	169	117	111	164	115	103	92	120	184	145	142	56
	Nashville	125	107	128	353	168	117	109	162	114	102	92	119	183	143	141	58
Texas	Amarillo	126	106	129	353	168	120	108	163	114	103	95	121	184	144	141	63
	Brownsville	150	139	157	406	200	132	143	198	138	123	101	139	216	176	174	43
	Dallas	131	116	136	358	175	119	119	171	120	107	94	124	190	152	150	50
	El Paso	126	110	129	358	169	116	113	164	115	103	90	119	184	145	142	52
	Fort Worth	128	113	132	358	171	117	116	167	117	104	90	120	186	148	145	50
	Houston	145	130	150	406	195	130	134	190	133	118	100	136	211	169	166	51
	Lubbock	126	107	128	353	168	118	110	163	114	103	93	120	183	144	141	58

Note: Figures include design energy requirements for heating, cooling, domestic hot water, fans, exhaust fans, heating and cooling auxiliaries, elevators, escalators and lighting.

Note: Space is reserved in this table for restaurants and industrial buildings.

Table I-3: ENERGY BUDGET LEVELS FOR COMMERCIAL AND MULTIFAMILY RESIDENTIAL BUILDING DESIGNS (in MBtu/sq. ft./yr) (CONT'D)

State	SMSA	Clinic	Community Center	Gymnasium	Hospital	Hotel/Motel	Multifamily High-Rise	Multifamily Low-Rise	Nursing Home	Office, Large	Office, Small	School, Elementary	School, Secondary	Shopping Center	Store	Theater/Auditorium	Warehouse
Texas	San Antonio	146	131	151	406	196	132	134	191	134	119	102	137	212	170	167	53
Utah	Salt Lake City	129	104	131	338	169	125	105	163	114	106	104	125	185	144	143	76
Vermont	Burlington	134	103	135	335	173	133	104	167	117	110	114	131	190	147	148	89
Virginia	Norfolk	123	105	125	353	165	115	108	160	112	100	90	117	180	141	138	56
	Richmond	129	107	131	353	171	122	109	165	116	105	98	123	186	146	144	66
Washington	Seattle	119	96	119	353	160	116	97	153	107	96	91	115	176	134	130	69
	Spokane	126	99	126	338	165	124	100	158	111	103	103	122	181	139	138	79
West Virginia	Charleston	128	106	130	353	170	123	108	164	115	105	99	123	186	145	143	68
Wisconsin	Madison	131	102	132	335	170	130	103	164	115	108	110	128	187	145	145	84
	Milwaukee	131	102	132	335	170	129	103	164	115	108	110	128	187	145	145	84
Wyoming	Cheyenne	128	100	129	338	167	127	101	161	113	105	106	125	184	142	141	82

Note: Figures include design energy requirements for heating, cooling, domestic hot water, fans, exhaust fans, heating and cooling auxiliaries, elevators, escalators and lighting.

Note: Space is reserved in this table for restaurants and industrial buildings.

BILLING CODE 6450-01-C

Appendix II: Climate Tables

1. *Purpose of this Appendix.* The purpose of this Appendix is twofold. First, it identifies the SMSA's and cities for which Energy Budget Levels have been established.

Second, this Appendix provides instructions and data for relating the location of the building design to one of the listed SMSA's or cities. Using the climate data identified this way, the Energy Budget Level can be selected and the Design Energy Consumption calculated.

2. *Contents of Table II–1.* Table II–1, which shall be used for all building designs for new buildings, has seven columns: Three identify the location and boundaries of each SMSA or city, and the remaining four are National Oceanic and Atmospheric Administration (NOAA) climatic data for each SMSA or city.

- Column 1: State. This is the principal State in which the SMSA or city is located. In some cases, an SMSA crosses State boundaries.
- Column 2: City. This is the principal name by which the SMSA or city is identified by the Department of Commerce.
- Column 3: Counties. This further identifies the area contained within the SMSA or city. Generally, these are whole counties, parishes or city limits. In some cases, only part of a county is included, in which case the Department of Commerce publication, "SMSA, 1975" shall be consulted for a precise boundary.
- Column 4: HDD (Base 60° F). This is the average annual heating degree-days calculated for a base of 60° F.
- Column 5: CDD (Base 50° F). This is the average annual cooling degree-days calculated for a base of 50° F.
- Column 6: Percent Possible Sunshine. This is the mean probable annual sunshine available, expressed as a percent.
- Column 7: Mean Dewpoint Temperature. This is the mean annual dewpoint temperature, expressed in °F.

3. *Instructions.* (a) If the building site is located within the boundaries of one of the SMSA's or cities listed in Table II–1, use that SMSA or city for the Energy Budget Level selection and use the associated climate data for the Design Energy Consumption calculation.

(b) If the building site is not located in one of the SMSA's or cities listed in Table II–1, use the following procedure to select the appropriate climate data that best fits the new building's intended location.

Step 1: Obtain from Publications, National Climatic Center, Federal Building, Asheville, NC 28801, the current "NOAA Local Climatological Data (LCD) Annual Summary with Comparative Data" for the LCD station closest to the new building's intended site, as well as the documents, "Degree Days to Selected Bases for First Order Tape Stations," and "Climate Atlas of the United States."

Step 2: Obtain the following from the documents listed in Step 1: (a) Total average annual heating degree-days, base 60° F; (b) total annual average cooling degree-days, base 50° F; (c) mean annual percent of possible sunshine, for those locations where available, and (d) mean annual dewpoint temperature, °F.

Step 3: Examine the data given in Table II–1 to select one or more SMSA's or cities for which the corresponding data does not vary from the data obtained in Step 2 by more than ±15 percent each for HDD, CDD, and, for locations where available, the mean annual percent possible sunshine.

Step 4: If there is only one SMSA or city which meets the criteria in Step 3, use that SMSA or city to select the Energy Budget Level and the climate data for that SMSA or city for the calculation of the Design Energy Consumption. If there is no SMSA or city which meets the criteria in Step 3, use the SMSA or city which is closest, as measured in air miles, and within 5 degrees latitude of the new building's intended site. If there is more than one SMSA or city meeting the criteria, proceed to Step 5.

Step 5: If there are two or more SMSA's or cities meeting the criteria in Step 3, select one SMSA or city in which the average annual dewpoint temperature is within ±15 percent of the data obtained in Step 2. If none of the SMSA's or cities which meet the criteria in Step 3 also meet the criteria for average annual dewpoint temperature in this Step, then select that SMSA or city from those meeting the criteria in Step 3 for which the average annual dewpoint temperature is closest to that obtained in Step 2. Use that SMSA or city to select the Energy Budget Level, and use the climate data associated with that SMSA or city to calculate the Design Energy Consumption for the building design.

Table II–1.—*SMSA and City Locations*

[NOAA climatic summary]

State	City	Counties	HDD (base 60°F)	CDD (base 50°F)	Percent possible sunshine	Mean dewpoint temperature °F annual
1	2	3	4	5	6	7
Alabama	Birmingham	Jefferson, St. Clair, Shelby, and Walker	1995	5403	59	51
Alabama	Mobile	Baldwin and Mobile	1062	6698	59	60
Arizona	Phoenix	Maricopa	899	7596	85	41
California	Bakersfield	Kern	1367	5835	78	45
California	Fresno	Fresno	1724	4986	78	45
California	Los Angeles	Los Angeles	522	5442	73	50
California	Oakland	Napa and Solano	1570	2963	66	47
California	Sacramento	Placer, Sacramento, and Yolo	1837	4286	77	46
California	San Diego	San Diego	648	4746	68	51
California	San Francisco	Alemeda, Contra Costa, Marin, San Francisco, and San Mateo.	1668	2832	66	47
Colorado	Denver	Adams, Arapahoe, Boulder, Douglas, Gilpin, and Jefferson.	4246	2993	67	28
Connecticut	Bridgeport	Fairfield and New Haven	4264	3064	60	42
Connecticut	Hartford	*Hartford, *Litchfield, *Middlesex, *New London, and *Tolland.	5085	2715	56	40
District of Columbia	Washington	District of Columbia, Charles (MD), Montgomery (MD), Prince Georges (MD), Alexandria City (VA), Fairfax City (VA), Falls Church City (VA), Arlington (VA), Fairfax (VA), Loudoun (VA), and Prince William (VA).	3182	4237	58	44
Florida	Jacksonville	Baker, Clay, Duval, Nassau, and St. Johns	788	6938	62	58
Florida	Miami	Dade	54	9308	67	66
Florida	Tampa	Hillsborough, Pasco, and Pinellas	364	8172	68	63

Table II-1.—*SMSA and City Locations*—Continued

[NOAA climatic summary]

State	City	Counties	HDD (base 60°F)	CDD (base 50°F)	Percent possible sunshine	Mean dewpoint temperature °F annual
1	2	3	4	5	6	7
Georgia	Atlanta	Butts, Cherokee, Clayton, Cobb, De Kalb, Douglas, Fayette, Forsythe, Fulton, Gwinett, Henry, Newton, Paulding, Rockdale, and Walton.	2189	4880	60	50
Idaho	Boise City	Ada	4533	2753	66	33
Illinois	Chicago	Cook, Du Page, Kane, McHenry, Will, and Lake	4952	3272	58	39
Illinois	Glenview	City limits	5245	2863	58	39
Indiana	Indianapolis	Boone, Hamilton, Hancock, Hendricks, Johnson, Marion, Morgaty, and Shelby.	4430	3441	59	42
Kansas	Dodge City	City limits	3963	4025	71	39
Kentucky	Louisville	Bullitt, Jefferson, Oldham, Clark (IN), and Floyd (IN)	3584	4005	59	45
Louisiana	Baton Rouge	Ascension Parrish, East Baton-Rouge, Livingston, West Baton, and Rouge.	1036	6685	59	60
Louisiana	Lake Charles	Calcasieu Parrish	908	5965	59	59
Louisiana	New Orleans	Jefferson, Orleans, St. Bernard, and St. Tammany	893	6956	59	60
Massachusetts	Boston	*Essex, *Middlesex, *Norfolk, *Plymouth, and Suffolk.	4383	2920	57	39
Maine	Portland	*Cumberland and *York	6035	1890	58	37
Michigan	Detroit	Lapeer, Livingston, Macomb, Oakland, St. Clair, and Wayne.	5167	2823	53	39
Minnesota	Minneapolis	Anoka, Carver, Chicago, Dakota, Hennepin, Ramsey, Scott, Washington Wright, and St. Croix (WI).	8842	2575	56	34
Mississippi	Jackson	Hinds and Rankin	1548	6086	59	54
Missouri	Columbia	Boone	3997	3919	61	43
Missiouri	Kansas	Cass, Clay, Jackson, Platte, Ray, Johnson (KS), and Wyandotte (KS).	4089	4085	65	43
Missouri	St. Louis	Franklin, Jefferson, St. Charles, St. Louis, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL).	3701	4232	61	44
Montana	Great Falls	Cascade	8248	2132	64	28
Nebraska	Omaha	Douglas, Sarpy, and Pottawattamie, (IA)	4907	3637	62	40
Nevada	Las Vegas	Clark	1770	6443	82	28
New Jersey	Newark	Essex, Morris, Somerset, and Union	3911	3533	59	42
New Mexico	Albuquerque	Bernalilbo and Sandoval	3234	4053	76	30
New York	Albany	Albany, Montgomery, Rensselaer, Saratoga, and Schenectady.	5596	2619	53	38
New York	Binghamton	Broome, Tioga, and Susquehanna (PA)	5908	2231	44	37
New York	Buffalo	Erie and Niagara	5591	2388	53	39
New York	New York	Bronx, Kings, New York, Putnam, Queens, Richmond, Rockland, Westchester, and Bergen (NJ).	3739	3653	59	42
North Carolina	Releigh	Durham, Orange, and Wake	2542	4482	61	48
North Dakota	Bismarck	City limits	7656	2248	59	30
Ohio	Akron	Portage and Summit	4971	2820	50	41
Ohio	Cincinnati	Clermont, Hamilton, Warren, Boone (KY), Campbell (KY), Kenton (KY), and Dearborn (IN).	3763	3864	57	43
Ohio	Cleveland	Cuyahoga, Geauga, Lake, and Medina	4901	2607	50	41
Ohio	Columbus	Delaware, Fairfield, Franklin, Madison, and Pickaway	4513	3183	55	42
Oklahoma	Oklahoma City	Canadian, Cleveland, McCain, Oklahoma, and Pottawatomie.	2760	4980	68	47
Oklahoma	Tulsa	Creek, Mayes, Osage, Rogers, Tulsa, and Wagoner	2750	5052	62	47
Oregon	Medford	City limits	3614	2685	58	40
Oregon	Portland	Clackamas, Multnomah, Washington, and Clark (WA)	5385	2309	48	44
Pennsylvania	Allentown	Carbon, Lehigh, Northampton, and Warren (NJ)	4818	3053	57	43
Pennsylvania	Philadelphia	Bucks, Chester, Delaware, Montgomery, Philadelphia, Burlington (NJ), Camden (NJ), and Cloucester (NJ).	3753	3679	57	43
Pennsylvania	Pittsburgh	Allegheny, Beaver, Washington, and Westmoreland	4694	2914	51	40
South Carolina	Charleston	Berkeley, Charleston, and Dorchester	1230	6334	66	55
Tennessee	Memphis	Shelby, Tipton, Crittenden (AR), and DeSota (MS)	2352	5339	64	50
Tennessee	Nashville	Cheatham, Davidson, Dickson, Robertson, Sumner, Williamson, and Wilson.	2758	4812	59	49
Texas	Amarillo	Potter and Randall	3156	4274	76	38
Texas	Brownsville	Cameron	336	8753	61	65
Texas	Dallas	Collin, Dallas, Denton, Ellis, Kaufman, Parker, and Rockwell.	1554	6467	68	52
Texas	Fort Worth	Hood, Johnson, Tarrant, and Wise	1616	6239	68	51
Texas	El Paso	El Paso	1833	5548	80	35
Texas	Houston	Brazoria, Fort Bend, Harris, Liberty, Montgomery, and Waller.	5864	7150	56	60
Texas	Lubbock	Lubbock	2603	4745	75	41
Texas	San Antonio	Bexar, Comal, and Guadalupe	956	7146	62	55
Utah	Salt Lake City	Davis, Salt Lake, Tooele, and Weber	4733	3094	69	32
Vermont	Burlington	City limit	8488	2180	46	36
Virginia	Norfolk	Chesapeake, Norfolk, Portsmouth, Suffolk, Virginia Beach, and Currituck (NC).	2516	4530	62	49
Virginia	Richmond	Charles City, Chesterfield, Goochland, Hanover, Henrico, and Powhatan.	2916	4276	61	47
Washington	Seattle	King and Snohmish	3657	1832	45	43
Washington	Spokane	Spokane	5420	2120	58	34
West Virginia	Charleston	Kanawha and Putnam	3500	3750	48	44
Wisconsin	Madison	Dane	6373	2361	56	37
Wisconsin	Milwaukee	Milwaukee, Ozaukee, Washington, and Waukesha	6080	2342	57	38
Wyoming	Cheyenne	City limits	5825	2003	66	27

*Part of a county.

Appendix III.—Approved Alternate Evaluation Techniques [Reserved]

Appendix IV.—Model Codes and Standards [Reserved]

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